Transactions of American Society for Steel Treating

Published Monthly — Cleveland, May, 1923 — Ten Dollars a Year

Vol. III — *Entered as second-class matter Feb. 7, 1921, at the post-office at Cleveland, Ohio, under the Act of March 3, 1879* — No. 8

SPECIAL FEATURES

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4600 Prospect Avenue

TRANSACTIONS

of the

American Society for Steel Treating

Vol. III | Cleveland, May, 1923 | No. 8

SECRETS

IT IS within the memory of most of us when the art of steel treating was regarded as a very secret and mysterious process, and it is to be noted that there are at the present time a few firms who still believe they have secret processes and methods by means of which they produce a superior product to that of others in a similar line.

These firms work on the principle that they should keep their heat treating department under lock and key and in fact build the place so secure and air-tight that it would not be possible to gather information even with the aid of a periscope and the proverbial knot-hole.

They work on the principle that what they have they will keep, and they rest secure on the supposition that what they have no one else will be able to secure. In other words, they have constructed around their heat treating department a windowless stone wall or they have pulled down the blinds so that no light from outside may be able to penerate the innermost recesses of their secret archives.

As stated before, there are few firms at the present time using this ancient attitude. The majority of them realize that their secret processes and methods are all "bunk" and that the development in metallurgical lines has been so pronounced that the average investigation will portray practically all of the secrets they think rest secure with them.

The remarkable change of attitude that has come over the various manufacturing industries with reference to granting the privilege of visitation or exchange of ideas is indeed quite pronounced and is a further evidence of the recognition of the application of scientific principles to the class of work in which they are engaged. Probably the largest factor contributing to the raising of the blinds or tearing down of the stone wall around the various heat treating rooms is the general trend of all organizations having for their principle the idea of service to their fellowmen. In direct contrast to their former habits, there are very few worthwhile establishments in the country today that do not have the open-door policy and are willing to have visitors go through their heat-treating departments and if they so desire, ask any questions they may and secure as much information as is their wish.

It is impossible that any single individual or firm knows all that is to be acquired with reference to the art of treating steel, and there are very few, who, meeting on common grounds and exchanging ideas with reference to methods and equipment, but may be of mutual benefit.

As an illustration of this point, we often recall the statement of the value of exchange of ideas. If you have a dollar and we have a dollar and

we exchange dollars then each of us still has a dollar. However, if you have an idea and we have an idea and we exchange ideas, then each of us has two ideas, which of course makes us better equipped to carry on our work and at the same time gives each individual a feeling of the application of the principle of reciprocity, which, after all, is an admirable solution to our many intricacies and vagaries of life.

When all things are summed up in the final reckoning there is no question but that the majority of individuals will be judged by the use they have made of the talents and opportunities given them, and inasmuch as we pass this way but once is it not a better plan to do all the good and service that it is possible for us to do so that it may be said of us that "we gave to the world the best we had," and in giving to the world the best we had there is no doubt but that "the best in the world will come back to us."

SHOOTING

WE ARE reminded of ancient days when among the hills and on the farm we were accustomed to accompany Dad on his squirrel hunting expeditions. Dad held the reputation of being a crack-shot and whenever he would come within the vicinity of one of the squirrel family, Dad would say "See that squirrel?" BANG! "Boy, go get that squirrel." Sure enough, the squirrel would respond to the crack of Dad's rifle and place himself in a convenient position for recovery.

This process would be continued and continued while we followed Dad with trembling hands and shivering knees, waiting for him to give us an opportunity to display the expertness with which we directed a rifle toward the fleeing squirrel.

Along about the seventh squirrel Dad would say "See that squirrel? Boy, take a shot at him!" And then we would with much fear and trembling raise the rifle to our shoulder and shoot at the squirrel. But, the squirrel did not respond as he did when father shot, consequently Dad would look at us with a certain amount of misapprobation for our marksmanship and would say "You do not shoot a high enough percentage," for Dad maintained all along that an individual must shoot 90 per cent or he wasn't shooting at all.

We could not shoot 90 per cent, and we wonder how many people in life "shoot 90 per cent," and that brings us to the point—Is 90 per cent the proper percentage to be attained in shooting at our object? Many of us will not make a record equivalent to that and no one, we believe, is able to shoot 100 per cent for a continuous time because it is human nature to err. Nevertheless, it seems the best thing possible for the majority of us to do is to train ourselves in marksmanship so that when a proposition comes before us for consideration we can aim at it true and level and with the confidence that every marksman must have if the response to his shot will be as he desires.

There is no doubt but that many individuals are too timid to shoot, but in work such as the members of our society are engaged in it is always necessary that there should be some mark, some object, to be obtained, and the better we train our marksmanship; the better we apply ourselves to the problems before us, the better we undertake to deliver a high percentage of hits, the better we will be qualified to perform and dispose of the functions and obligations that are resting upon us in the discharge of our duties.

SHORTER TESTING TIME NECESSARY

RESISTANCE to fatigue and impact are two properties of materials for which there is vital need for greater information. Both of these are of special moment in the automotive industry. Much work has been done on both, yet the field has scarcely been touched.

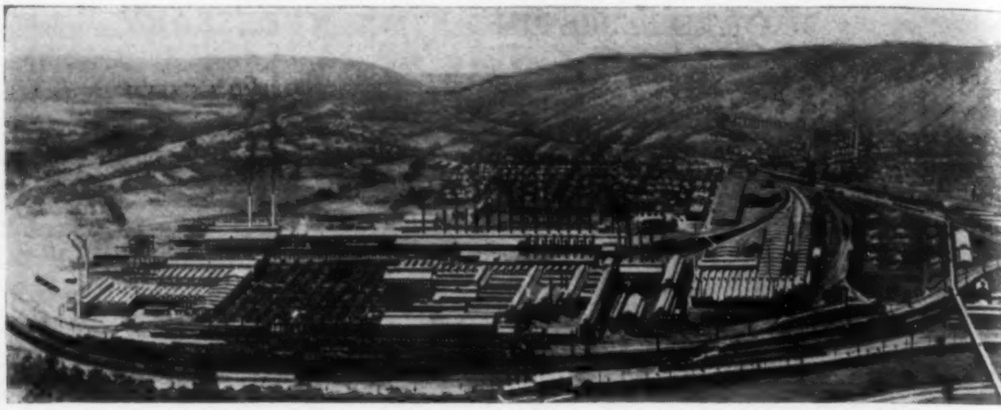
Many of the impact results are inconclusive. Some even contradict earlier tests done on supposedly similar material and under supposedly similar conditions. Reliable investigators feel that the limitations of the test itself render it difficult, if not impossible, to get check results closer than fifty per cent. It is doubtful if the present type of generally accepted impact test can even be refined to a degree that will produce as close check results as the tensile test. It is expected, though, that with the adoption of a more standard type of testing machine, a more standard type of test piece and more standard control of test operations that the marked disparity in present day tests results will be greatly reduced.

Engineers have been endeavoring for some time to determine the fatigue properties of various metals under various load conditions. The Wöhler method has been the one generally used. It consists in rotating a standard test piece under a definite load for a given period. At best it is an extremely slow test. In many instances over a month of continuous operation is necessary for the determination of the fatigue properties of a single specimen. Appreciating the multiplicity of compositions and loads and in the case of steels, and even in some cases non-ferrous metal, the large number of possible heat treatments, the laboriousness and slowness, to say nothing of the cost of the present method of testing, is apparent to all. At our present rate of progress a hundred years or more would elapse before we would even approach our present knowledge of the tensile properties of material.

The engineers of this country, therefore, should receive with much enthusiasm a test procedure for the determination of fatigue properties which has recently been developed in England. We are informed that it is as rapid as our tensile test and that the test itself can be performed with the same facility and care.

Essentially the test proper consists in rotating a specimen under a given load. Directed against the end of the specimen to which is attached a mirror, is a beam of light which is in turn projected on a scale. This projected beam undergoes but a slight vertical motion when the test specimen is rotated under its fatigue limit but as soon as the fatigue limit is passed the vertical motion of the beam of light is pronounced. This test was described by Dr. Rosenhain in one of his lectures at the time of his visit to this country in February and March of this year. It is also described in the 1922 edition of *Mechanical Testing* by Batson and Hyde. It warrants a careful consideration by all engineers concerned with fatigue properties in metals.

A. E. W.



Bethlehem Plant, Beth

EASTERN SECTIONAL MEETING OF A. S. S. T. AT BETHLEHEM, JUNE 14 AND 15, PROMISES TO BE AN INTERESTING SESSION

THE Eastern Sectional meeting at Bethlehem in June promises to be very interesting. The Lehigh Valley chapter, the hosts at this meeting, have prepared a full program, which includes entertainment for the ladies that will make their trip to Bethlehem one to be remembered.

The business meeting the first day will be held in the Hotel Bethlehem. This hotel, newly built and opened to the public last fall, has splendid accommodations for a meeting of this character, and compares favorably with the modern hotels of the largest cities.

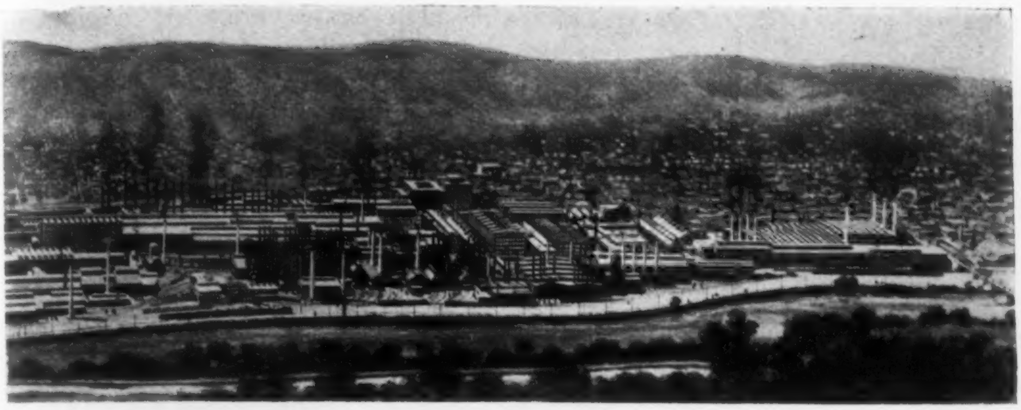
The trip through the Bethlehem plant of Bethlehem Steel Company scheduled for the morning of Friday, June 15, presents an unusual opportunity for members to see the operations in the manufacture of steel.

The steel works at Bethlehem, Pa., extend for a distance of 3¼ miles along the south bank of the Lehigh river, and comprise the Lehigh plant, the Saucon plant and the Northampton plant of Bethlehem Steel Company. These plants occupy an area of 820 acres for manufacture; 1,680 acres additional are owned by the company for plant purposes in Bethlehem. Five railroads enter the city of Bethlehem and serve the steel works—the Lehigh Valley, the Central Railroad of New Jersey, the Philadelphia and Reading, the Lehigh and New England, and the Philadelphia, Bethlehem and New England. Interlacing the Bethlehem yards are 100 miles of standard gage and 14¼ miles of narrow gage railway tracks. The rolling equipment includes 28 standard gage and 21 narrow gage locomotives, and 565 standard gage and 190 narrow gage cars.

The plants at Bethlehem include seven blast furnaces; thirty-four open hearth furnaces; three Bessemer converters; two electric furnaces; iron, steel and brass foundries; ingot mold foundry; treatment shops; six machine shops, rolling mills to produce special and alloy bars; rail and structural mills; fabricating shops; drop, press and hammer forges; two projectile shops with forge, treatment and machine divisions; an armor plate plant; and coke and coke by-products plant.

Members undoubtedly will be interested in the production of steel by the Bessemer and open-hearth methods, and the equipment at the works includes the following:

Lehigh plant: Open-hearth No. 1, consisting of one 10-ton furnace, two 20-ton furnaces, five 40-ton furnaces and three 50-ton furnaces.



lehem Steel Company

Open-hearth No. 3, consisting of four 50-ton basic furnaces and one 50-ton acid furnace.

Two electric furnaces, including one 10-ton and one 3-ton furnace.

The major portion of the output of the above furnaces is special and alloy steels.

Saucon plant: This is a separate unit for the manufacture of rails and

Hotel Bethlehem

structural steel, it consists of: Open-hearths Nos. 2 and 4, including two 200-ton tilting furnaces and sixteen 75-ton stationary furnaces. The Bessemer department, consisting of three 20-ton converters.

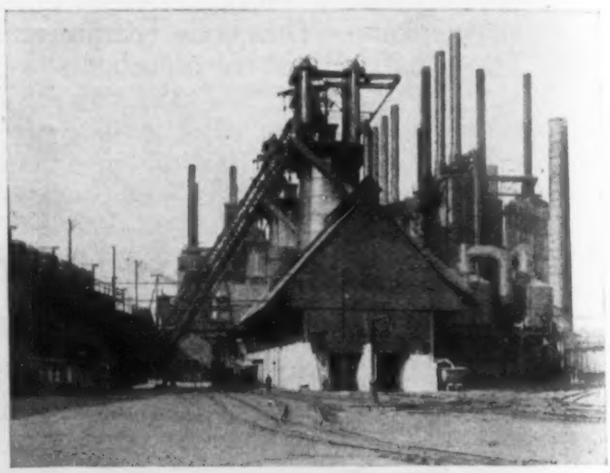
Ore Handling Crane and Storage

The wide range of equipment of the rolling mills at Bethlehem is seen from the following:

Lehigh mills: Two 22-inch merchant mills; two 12-inch merchant mills; one 10-inch merchant mill; one 9-inch merchant mill; one 8-inch merchant mill; one 35-inch blooming mill; and one 18-inch continuous billet mill; all of which are devoted to special and alloy steels.

Saucon mills: One 48-inch structural (gray) mill; one 42-inch structural (gray) mill; one 28-inch structural mill; one 18-inch structural mill; one 12-inch structural mill; one 46-inch blooming mill; two 40-inch blooming mills; one 30-inch billet mill; and one 28-inch rail mill.

The division of the Bethlehem works devoted to coke production is known as the Northampton plant. This plant produces coke and coke by-products, and is equipped with four hundred and twenty-four 13½-ton Koppers ovens, consuming an average of 6400 tons of coal daily. The average production of the ovens amounts to 4,500 tons of coke, 45,000,000 feet of gas, 150,000 pounds of ammonium sulphate, 45,000 gallons of tar, and 11,000 gallons of light oil daily.



View of Blast Furnace at Bethlehem

The wide diversity of the products of the modern steel plant is not always realized, even by men engaged in auxiliary lines of steel making or working. The products of the Bethlehem plant include:

Bethlehem beams, girders and columns; standard beams, channels and angles; fabricated steel for buildings and bridges, etc.

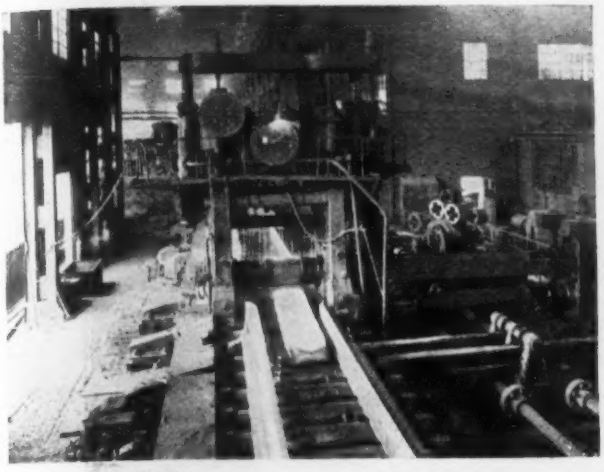
Pig iron, ingots, blooms, billets, bars, slabs and rails.

Tool steel, standard alloy and special steels.

Ingot molds; brass, iron and steel foundry products.

Forgings (drop, hammered, hy-

Tapping Steel From 200-Ton Tilting Open-Hearth Furnace



Rolling an Ingot on a 35-Inch Blooming Mill

draulically pressed); marine and stationary engine cranks (forged hollow or built up).

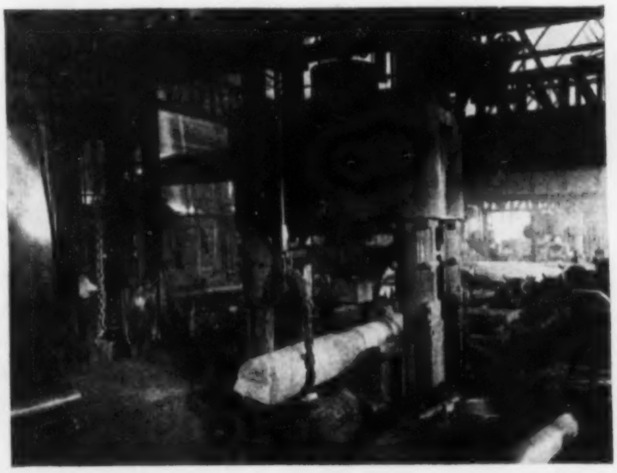
Forged armor plate; gun carriages; heavy and light ordnance of all calibres; projectiles of all sizes, shrapnel, high explosive shells, fuses; air flasks.

Gas and diesel oil engines; large pumping engines; blowing engines; rolling mill machinery; boilermakers' tools; bridge shop tools; hydraulic machinery; special machinery.

Rolled steel motor truck wheels.

Coke and coke by-products, such as tar, benzol, toluol, retort carbon, motor fuel, ammonium sulphate, crude naphthalene.

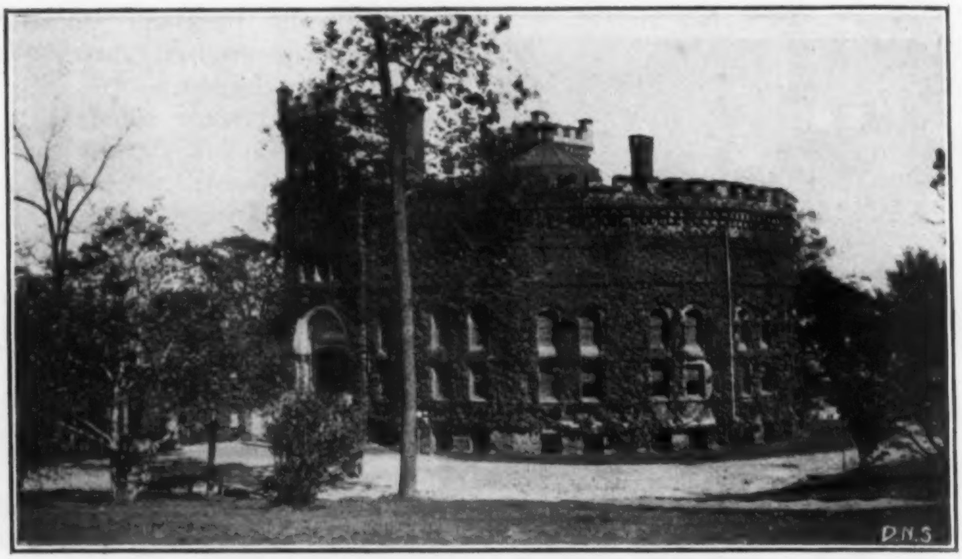
The above list indicates what is manufactured at the Bethlehem plant. Other steel making plants of Bethlehem Steel company are located at Steelton, Lebanon, Reading, Johnstown, and Coatesville, Pennsylvania; at Lackawanna, New York; and at Sparrow's Point, Md.



Hydraulic Forging Press—Capacity 5000 Tons

After the trip of inspection through the Bethlehem Steel company plant Friday morning, luncheon will be served to the members in the dining hall of Lehigh university. The afternoon business meeting will be held in the recreation building of the university, whose president, Dr. C. F. Richards, has offered these facilities to the Lehigh Valley chapter for the use of their guests. The excellent work at Lehigh university, in metallurgical, mining, chemical and other engineering courses is well known to the members of this society, and an opportunity to visit the university should be embraced by every member. At the time of the June meeting the university campus and its surroundings are especially attractive and

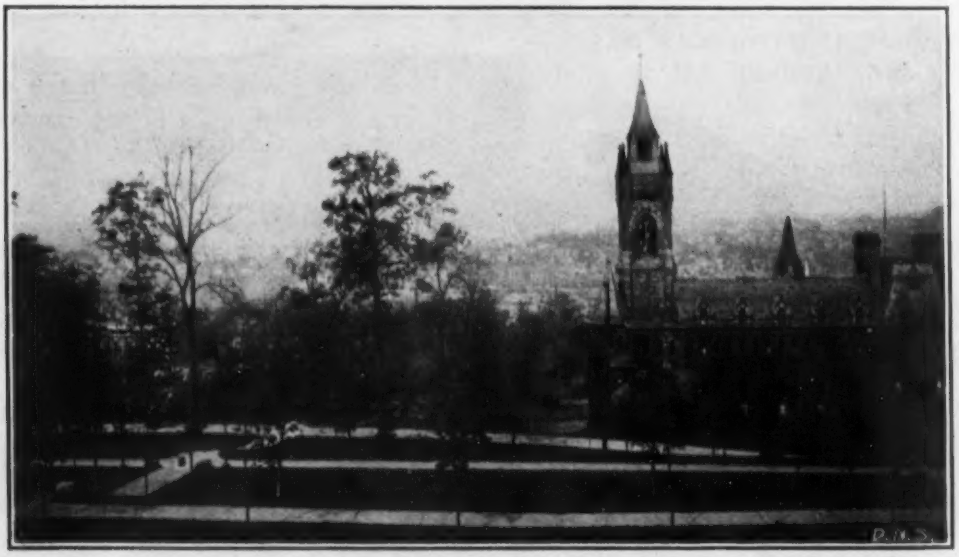
Main Office Building, Bethlehem Steel Co., Bethlehem, Pa.



Library of Lehigh University

the sessions here will be a very pleasant experience to all who may attend.

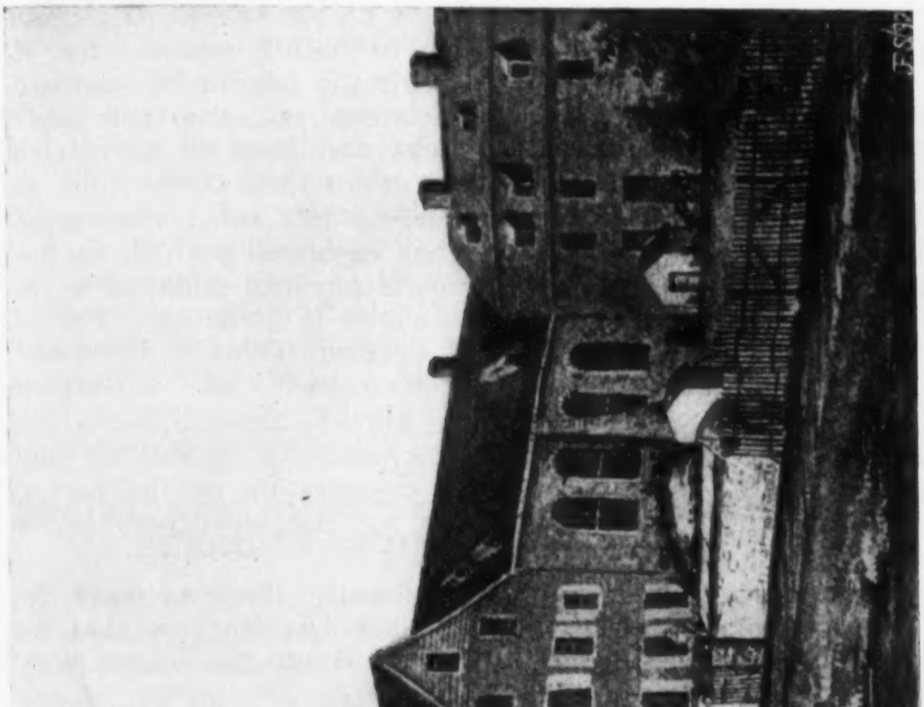
The entertainment to be provided for the ladies as noted in the May issue of TRANSACTIONS, includes visits to many interesting points in the vicinity. Bethlehem is especially rich in historical associations, being founded nearly 200 years ago by Moravians who came here from Austria and Germany. Like many others of the early settlers of this country, they came seeking an opportunity for freedom in religious worship. For many years the customs of their country were maintained in their settlement, and the influence is still strongly felt. Even as early as Revolutionary times the customs of this community were known as distinctive, and many personages of note, as George Washington, Martha Washington, LaFayette, Benjamin Franklin, journeyed to Bethlehem and visited the places of interest. A deep interest in education was characteristic of the early settlers, and a number of schools were founded. Among these, the Moravian college for women enjoys the distinction



Parker Hall, Lehigh University, Where Business Meeting Will Be Held June 15

of being the oldest college for women in the United States, if not in the world. Some of the buildings still in use date back to 1742.

The auto trip planned, probably to the famous Delaware Water Gap, should be a very pleasant outing.



Old Moravian Buildings in Bethlehem

Moravian Church 1806 — Community House 1742 — Old Chapel 1755 — Bell House 1746

The Lehigh Valley chapter is making every effort toward holding an interesting and enjoyable meeting for its members and friends and all who can possibly do so are urged to attend the meeting.

Make hotel reservations with George C. Lilly, Superintendent of Heat Treating, Bethlehem Steel Company, Bethlehem, Pa.

DR. GEORGE K. BURGESS APPOINTED DIRECTOR OF THE BUREAU OF STANDARDS

THE Honorable Herbert Hoover, secretary of the department of commerce, under which department falls the United States bureau of standards, has announced the appointment of Dr. George K. Burgess as director of the bureau of standards at Washington.

Dr. Burgess has been associated with the bureau of standards for the past 20 years starting out as associate physicist in the year 1903. In 1913 he was appointed chief physicist and head of the division of metallurgy, which position he has held up to the present time.

In his 20 years of service, Dr. Burgess has aided very materially the rapid growth of the bureau which has expanded both in the number of building and laboratories constituting its physical make-up as well as the personnel and scope of the work which it is doing. The bureau stands very high in the technical and scientific fields and we are sure this high standard has been largely due to the work of Dr. Burgess.

In accepting the directorship of the bureau, Dr. Burgess assumes a grave responsibility, but one which he is perfectly capable of handling. He is assured of the most harmonious co-operation on the part of the men in the industrial field with whom for the most part he is personally acquainted.

It is with great satisfaction and pleasure that we have learned of this appointment and we wish to assure Dr. Burgess that he will have the sincere and hearty support of the American Society for Steel Treating in his new work.

Dr. Burgess has been a member of the society since its inception and has ardently supported it in its work during the past years.

We are looking forward to many notable accomplishments under the able guidance of the new director.

GUESSING VERSUS REASONING

THOSE who attended the annual convention of the American Society for Steel Treating held in Detroit last October will recall that a guessing contest was conducted by the Atlas Steel Corp. The contest called for the guessing of the nature of a steel which was exhibited. The exhibit consisted of five pieces of this steel, one showing the fracture, the other four showing polished cross-sections each etched with a different acid. First prize of $50.00 went to W. H. Blocksidge, metallurgist of the J. H. Williams Co., Buffalo, N. Y., second prize went to C. A. Smith, Coraopolis, Pa., and third prize went to Mrs. F. P. Gilligan, Hartford, Conn. The material was a piece of low-carbon bessemer steel.

	Carbon Per cent	Manganese Per cent	Silicon Per cent
Average analysis	0.13	0.58	0.03
First prize guess	0.17	0.60	0.09

The other guesses deviated interestingly from this, in many cases to automotive steels, spring steels and high speed steels. The reasoning

back of those guesses is not known, but it will perhaps be of interest to take advantage of the first prizewinner's permission to quote his reasoning.

"Upon examining the fracture of the bar, the average man would probably say that it was 0.60 per cent carbon steel, but on a little closer examination, he would observe a certain paleness in this fracture that is not common to a 0.60 per cent carbon steel, hence a question would arise. The light color of the metal etch would indicate one of two things, namely; a low carbon, or an alloy steel, probably high chrome. Next, the sulphuric acid etch indicated that it was not a high carbon alloy steel, but a low carbon product which might have been an alloy steel. The other etch exhibited considerable segregation in the bar, so by arguing that no reputable alloy steel mill would put out such segregated steel, it therefore, must be a low carbon plain steel.

"Being a low carbon steel, the fracture indicated that it was brittle. The question then arises as to what is the analysis of a low carbon brittle steel?. Most likely a bessemer steel; consequently, the average bessemer screw stock will run 0.17 per cent carbon, 0.60 per cent managese and low silicon, say 0.09 per cent—Presto and the prize."

FINANCIAL STATEMENT OF THE AMERICAN SOCIETY FOR STEEL TREATING FOR THE YEAR 1922

THE report of the auditors upon the result of their audit of the books of the society is submitted herewith.

Their statement shows that the society has not only lived within its income during the past year but has made substantial additions to its reserves and surplus.

The size to which the business of the society has grown is well illustrated by the fact that the "Income and Expense Statement" shows a turnover for the year of $75,000.

The sum of $3000 was set aside by the board of directors for the principal of the Henry Marion Howe Medal fund.

The sum of $10,000 was set aside by the board of directors from the proceeds of the Detroit convention as a permanent convention reserve in order to fortify the society against disaster from a financially unsuccessful convention.

The principal of these two funds has recently been invested in United States government bonds.

The full details of the auditor's report are on file at the society offices and are open to inspection of all interested members.

Signed—J. V. Emmons, Treasurer.

EXHIBIT A

BALANCE SHEET

AMERICAN SOCIETY FOR STEEL TREATING

December 30, 1922

ASSETS

CASH

The Cleveland Trust Co. (Commerical account)	$ 2,812.44	
The Cleveland Trust Co. (Savings account)	4,518.80	
The Equity Savings & Loan Co. (Savings account)	2,575.63	
The Union Trust Co. (Savings account)	1,040.40	$10,947.27

INVESTMENTS

Euclid Village, Ohio 6% Water Bonds		$3,000.00		
U. S. Treasury Certificates		2,015.00		
Certificates of Deposit (Equity Savings & Loan)		9,500.00	$14,515.00	

ACCOUNTS RECEIVABLE

Advertising	$ 2,972.62			
Detroit 1922 Convention	141.97			
Sundry Accounts & Advances	656.00	3,770.59		
Less—Reserve for Doubtful Accounts		1,000.00	2,770.59	
Inventory paper & bindery stock			962.00	
Furniture and fixtures (book value less depreciation)			1,235.62	
Pittsburgh convention expense prepaid			960.83	$31,391.31

LIABILITIES RESERVES AND SURPLUS

Accounts payable	393.87	
Reserve for dues paid in advance	10,000.00	
Permanent convention reserve	10,000.00	
Henry Marion Howe Medal Fund	3,000.00	
Surplus	7,997.44	31,391.31

CERTIFICATE

We have made an audit of the books and record of the AMERICAN SOCIETY FOR STEEL TREATING for the year ended December 30, 1922 and in our opinion, the above Balance Sheet—Exhibit A together with the annexed Income and Expense Statement—Exhibit B correctly present its financial status at December 30, 1922 and a history of its financial transactions for the period under review, basing the income from dues upon cash receipts and other income upon accruals.

Respectfully submitted,

NAU, RUSK & SWEARINGEN,

Certified Public Accountants.

EXHIBIT B

INCOME & EXPENSE STATEMENT
AMERICAN SOCIETY FOR STEEL TREATING
Year ending December 30, 1922.

INCOME

Advertising	$ 19,909.54	
Membership dues	27,714.64	
Detroit 1922 convention	24,772.78	
Transaction sales	985.90	
Bindery sales	300.01	
Reprint sales	384.90	
Pins and buttons sales	28.00	
Discount on purchases	83.35	
Interest earned	798.93	
Miscellaneous income	79.53	
Collections (Accounts receivable previously written off)	23.80	$75,081.38

EXPENSES

Returned to local chapters		10,051.95
Bindery		312.55
Reprints		286.81
Transactions		
Paper and cover stock	$2,263.64	
Printing	7,527.36	
Editor	2,730.00	
Editorial assistance	308.35	
Editorial traveling expense	238.05	
Clerical	837.95	
Commissions	618.60	
Cuts	1,407.85	
Postage	385.27	
Executive salary	1,500.00	
Rent	525.00	
Stationery	131.76	

Office supplies	$ 65.84		
Mailing and miscellaneous expense	223.87	$18,763.54	
Secretaries' office			
Executive salary	2,400.00		
Rent	1,077.00		
Clerical	742.16		
Traveling	831.10		
Stationery	263.29		
Office supplies	154.88		
Postage	635.35		
Telephone, telegraph and miscellaneous office expense	664.23	6,768.01	
President's office			
Traveling expense	775.59		
Telephone, telegraph and miscellaneous office expense	337.86	1,113.45	
Treasurer's office			
Bookkeeper's salary	720.00		
Auditing	225.00		
Stationery, postage and miscellaneous expense	106.79	1,051.79	
Detroit convention			
Convention expense—General	12,566.13		
Executive salary	2,100.00	14,666.13	
Director's expense			
Traveling	1,355.16		
Miscellaneous	308.11	1,663.27	
National committees			
Traveling	553.12		
Miscellaneous	67.31	620.43	
Sectional meetings			
New York	400.02		
Pittsburgh	432.36	832.38	
Increase of membership		771.98	
Bad debts (including $200.00 added to reserve)		723.24	
Discounts allowed		32.63	
Bank exchange		3.04	
Euclid village bond premium charged off		101.64	
Incidentals		401.84	
Balance disposed of as follows:			
Permanent convention reserve	10,000.00		
Henry Marion Howe Medal Fund	3,000.00		
Addition to reserve for prepaid dues	500.00		
Allowance for depreciation of furniture and fixtures	1,000.00		
Additon to surplus	2,416.70	16,916.70	
			$75,081.38

NEW CHAPTER IN LOS ANGELES

ALL of the older chapters of the American Society for Steel Treating welcome the new arrival of a chapter from the land of sunshine and flowers and wish for it a continuance of the success with which it has so auspiciously begun its career.

In January, Charles P. Miller, associated with the Raymond G. Osborne Co., called together a number of interested individuals in Los Angeles and vicinity who had previously expressed the desire that something definite should be done in establishing a chapter of the American Society for Steel Treating. At this preliminary meeting an organization committee was formed of which Mr. Miller was elected acting-secretary.

A formal application for a charter was presented to the board of directors of the American Society for Steel Treating and acted upon favorably at their meeting on February 10.

On March 14, at the office of the Rich Steel Products Co., the

ROBERT B. DUNSMORE
Chairman—Los Angeles Chapter

E. C. LeMUNYON
Vice Chairman—Los Angeles Chapter

JAMES H. KNAPP
Sec'y-Treas.—Los Angeles Chapter

first and organization meeting of the Los Angeles chapter was held. This meeting was attended by twenty-three signers of the application for the chapter and was presided over temporarily by Mr. Fitzhugh as chairman with Mr. Miller acting as secretary.

After a general discussion of the purpose of the meeting and some very interesting remarks by some of the members of the society who had been connected with other chapters, the chairman called for nominations of chairman, vice chairman, secretary-treasurer and members of the executive committee to hold office until May, 1924. The following officers were elected:

Chairman

Robert B. Dunsmore, metallurgist

Vice Chairman

E. C. LeMunyon, vice president Rocky Mountain Steel Products Co.

Secretary-Treasurer

James H. Knapp, manufacturer's representative

Members of the Executive Committee

C. P. Miller, Raymond G. Osborne Co.
J. A. Baker, works manager Rich Steel Products Co.
James M. Fitzhugh, production manager Llewellyn Iron Works Torrance plant
Wm. W. Farrar, district manager, Ludlum Steel Co.
H. J. Barton, manager, Jamison Steel Co.

At this meeting it was decided to hold regular meetings on the first Wednesday of each month at 7:30 p. m.

Much credit is due to the older members of the society as well as as the new ones who have interested themselves in the formation of the local chapter, and judging from the caliber of the officers elected as well as the positions held by the members so far elected, the chapter has every possibility of having a very successful career and will fill a long needed position in the Los Angeles territory.

The officers and members of the Los Angeles chapter have the best wishes of the entire membership for continuing the successful work so far accomplished by the society, and express the hope that the chapter will take its place in the community as a real service and benefit to the iron and steel industry.

COARSE GRAINED DROP FORGINGS—THEIR DETECTION AND CORRECTION

By L. S. Cope

Abstract

As indicated in the title of this paper, the author has reviewed in considerable detail those factors which chiefly contribute to a coarse grained structure in drop forgings. Excessively high forging temperatures with an insufficient amount of mechanical work are the two main contributing factors to this condition.

Methods of detecting coarse grained fractures are discussed and the author describes a method devised by himself which has proven very satisfactory and one which can be expanded to a 100 *per cent inspection of the product of a shop. Numerous illustrations are included in this paper as evidence of the practicability of the method.*

The author discusses the various methods of heat treatment which are applied to coarse grained forgings in an endeavor to reclaim them for service, stating that most of the heat treatments used are "freak" treatments and are of little practical value. The importance of proper furnace design, proper heating temperatures and proper reductions in hammering the metal into the dies is of prime importance.

IT frequently happens that when examination is made of fractured hardened steel pieces which represent a batch of material just finished, it is found that several of the pieces are very coarse grained. Sometimes it is not until the hardened pieces are on their way through the plant being fabricated into finished articles, that one of them is accidently dropped on the floor, breaking into many pieces, revealing a very coarse grained fracture.

On the other hand perhaps the pieces have for some reason escaped the fracture inspection of the heat-treating department and have gone through the subsequent manufacturing processes without being ruptured and finally reach the ultimate user who puts them into service. Early failure occurs in service and typical broken pieces are returned to the manufacturer.

After examining the course fracture, the manufacturer probably sends a telegram to the "poor" steel manufacturer which which might read something like this:

> "Your steel coming very poorly. Fracture looks like sash-weight iron. Something must be done at once. Send representative."

The steel manufacturer is blamed for the faulty steel which caused this coarse grained and weak fracture and he in turn blames the heat treater, but the heat treater furnishes evidence that his pyrometer control, his furnaces, his fuel, etc., are ideal, and so a two-sided battle wages; with a third party, the foreman in charge of the forge shop continually supplying the ammunition for the battle.

It is not the purpose of the writer to convey the impression that all coarse grain in heat-treated steel pieces is due to faulty forging, but he does

A paper presented before a meeting of the Society. The author, L. S. Cope, is metallurgist with the National Screw & Mfg. Co., Cleveland, Ohio.

infer that faulty forging is directly responsible for a large percentage of the poor results obtained in the hardening or subsequent operations, whatever they may be. A piece of steel improperly forged will not respond to anything short of "freak" after-treatment, and if the piece is improperly forged it is in many cases ruined and cannot be reclaimed by any heat treatment. There are several "freak" methods of heat treating and partially reclaiming a faulty forging, but this should not justify faulty forging methods. If a man becomes ill, he can very often be cured by proper treatment and medicine, but it doesn't always follow that he is as healthy after the cure, as he would have been had he never become ill.

Many plants have specialists whose duty it is to carefully watch all heat treatment. To these men the writer would say "your duty is to watch the steel from the time it is introduced into the forge furnace, through its annealing, hardening and until it finally comes out of the tempering bath". It is just as important to investigate and correct and maintain proper forging heats as it is to maintain proper hardening heats. The one effort is useless without the other.

The Cause of Faulty Forgings

There are several things that happen in the forging operation to cause faulty forgings. Many hammermen are accustomed to working on steel made "mushy" and "plastic" by high furnace temperatures, and the forging is very often finished at high temperatures. If forging could be prolonged so that the finishing temperature is just a little above the critical range, it would then make little difference what the temperature of the bar was when it was taken from the forge furnace, as it is the finishing temperature which determines the quality of the forging.

It usually happens however, that the forged piece has to be completed in a given length of time, or in a given number of blows of the hammer. The metal has then filled up the cavities in the dies and to continue hammering further would merely result in the faces of the dies striking each other or striking the "flash" and doing little or no work on the forged piece. So it is not always possible to start with a very hot bar and prolong the working to a proper finishing temperature. In order, therefore, to adopt the practice of low finishing temperatures, we must likewise expect to heat the bars to lower initial temperatures, according to the size and character of the forging.

Fig. 1 is a diagram showing the effect of hot working upon the structure of steel. The two top parallel lines represent the solidification range. The middle pair of parallel lines represent the critical range and the bottom line represents atmospheric temperature. The width of the vertical band represents the size of the grain. In interpreting this diagram let us start with steel in the molten state as at "A". As it cools through the solidification range a coarse crystalline structure is formed, as represented by the distance between the two diverging lines starting from point "A". As the steel further cools the grain size gradually increases until the critical range is reached, when the grain size remains constant down to atmospheric temperature.

In studying this diagram bear in mind that it is the width of these vertical bands that represents the grain size and the cross hatched lines are merely for the purpose of darkening the bands. If we now reheat this "ingot" no change takes place in the grain size until the critical range is reached, at which time the grain size "tends" to decrease. Further heating above this critical range causes the grain size to again increase in size until

when point "B" is reached, the grain size is very course. Point "B" is what might be called the temperature and grain size of a bar which has been heated to a high temperature for forging.

As just stated, in heating through the critical range, the grain size "tends" to decrease, and this is really all it does do. Very course grain has

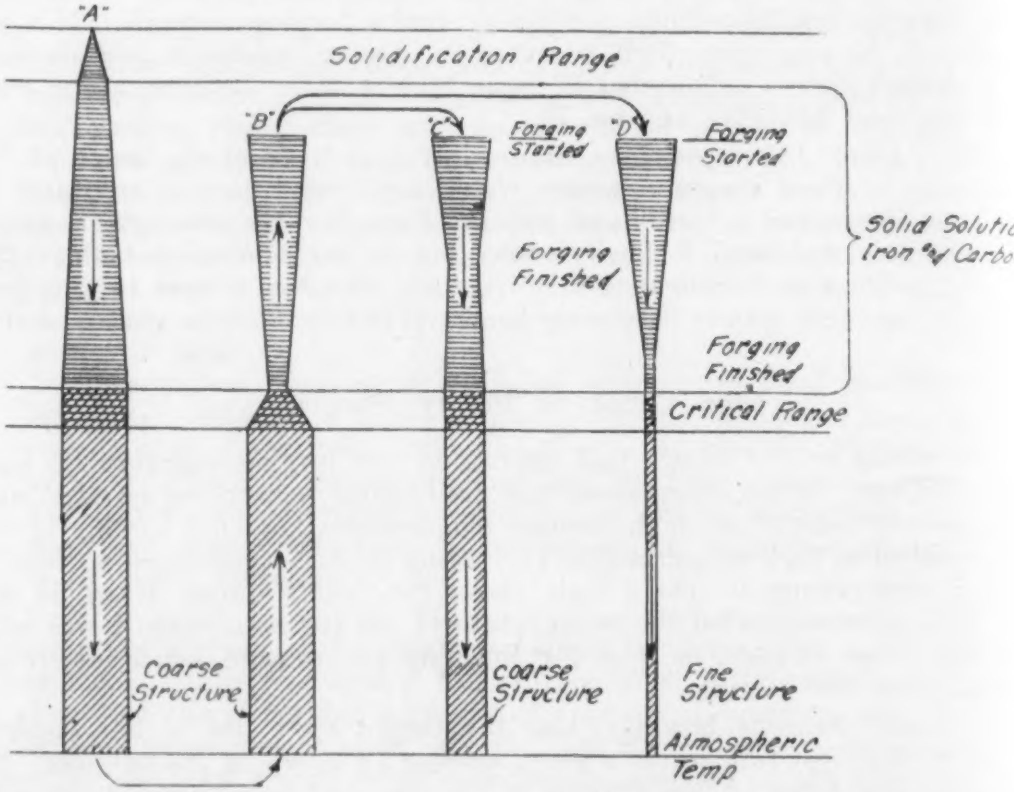


Fig. 1—Diagram Showing The Effect Of Hot Working Upon The Structure Of Steel.

a tendency to persist, even after prolonged annealing. If it were possible to break up "ingotism" (which is the common name given to the presence of very coarse grain in ingots) by a prolonged anneal, it would seem to be the proper thing for a manufacturer of milling cutters (for example) to buy round cast ingots and thoroughly anneal them, and then cut off discs and proceed to make milling cutters, knowing that he had avoided the steel mill rolling charges. All of which is absurd. The steel manufacturer rolls his material with two objects in view. First, to reduce the section and change it to the desired shape. Second, to reduce the grain size. No treatment, other than mechanical working will reduce this coarse grain size, so that it is fit for commercial purposes.

Let us study the diagram a little further. After the piece has been reheated to "B", suppose we withdraw it from the furnace and start hammering, and continue this hammering until a temperature of 1700 or 1750 degrees Fahr. is reached, after which hammering is stopped. The grain size has been somewhat reduced, although it is still coarse, and further cooling after the hammering is stopped, results in a growth of grain size until the critical range is reached, where the grain size becomes fixed and remains so down to atmospheric temperature. It is still coarse grained, although not quite as coarse as the ingot.

If we reheat this coarse grained forging we will find that we can par-

tially refine the grain by several "freak" methods, but after all, only partially. This forging "C" is virtually an "ingot" and shows signs of "ingotism". If, however, we forge as at "D" and finish just above and near the critical range, it is obvious that we obtain the maximum refinement of grain. We can now take the forging "C" and reforge it as at "D" which will result in refinement of the grain.

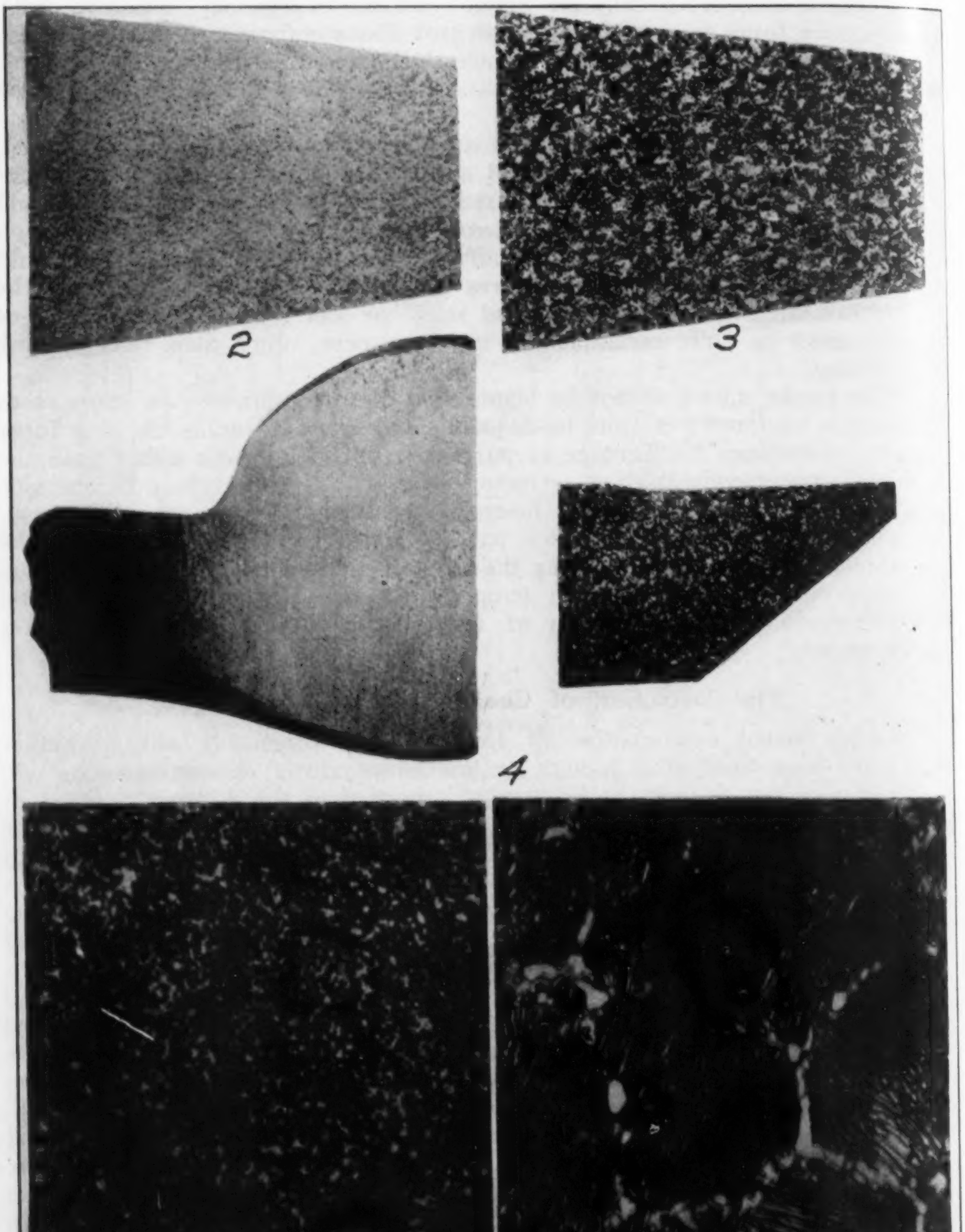
A forging manufacturer usually specifies hot rolled stock un-annealed. If the stock as received from the steel mill is in a slightly coarse grained condition, it would make but little difference, provided the manufacturer would conduct his forging at low finishing temperatures as at "D", and even though the steel mill supplied well annealed and fine grained stock, the forger would ruin it by high finishing temperatures as at "C". In the latter case the forger has virtually "recast" the good steel bar and remade it into an ingot which cannot be fully reclaimed by any treatment, other than rehammering or rerolling.

The forger cannot always be blamed for these conditions. In many cases his furnace equipment is quite inadequate. Sometimes he builds his own forge furnace, sometimes his furnace is purchased outside, but in either case the ordinary variety consists of a refractory box with a burner hole in one side and an opening in the front for inserting the bars to be heated. Then too, the working opening is usually too narrow and a high temperature must be maintained in the furnace to bring the bars up to forging temperature within the required time. Usually the temperatures are altogether too high and very nonuniform. The question of forge furnaces will be discussed later in this paper.

The Detection of Coarse Grain in Forgings

Under visual examination all forgings look practically alike, whether they have been finished at a high or low temperature. Sometimes one will find the very hot forging to be "scaled" more than the forging finished at relatively low temperatures, but the difference is not great enough to provide a positive means of detection. It is of course always possible to break a forging and study the fresh fracture, and also to prepare photomicrographs which will tell the story. The forged piece, however, may be an expensive one and for this reason the inspectors may be very reluctant to break it. Even if such inspection were made at the sacrifice of several forged pieces, this examination would be made on only a few pieces selected at random and would not assure the inspector that the forgings he had just passed or rejected were all exactly like the sample tested. In fact he might select one sample out of ten forgings, find that sample to be fine grained and put his O. K. on it, whereas 5 forgings out of the remaining 9 might be coarse grained. Studying the fracture or the photomicrograph are both positive means of determining whether the particular piece tested is overheated, or properly heated, and for the purpose of investigation are absolutely necessary. For the "control" of the product however, and for insuring the proper quality in every piece turned out, other means must be adopted.

The writer has found that a solution consisting of 2 parts of nitric acid and 3 parts of water, make a positive detector for coarse grain in forgings without in the least injuring the forging. The scale must first be removed from the forging or from a spot on the forging, or better still the etching operation can be performed after the forging has undergone its first milling, rough grinding or machining operation, which will lay bare the metallic surface and be well under the decarburized surface. The piece or pieces are



Figs. 2 and 3—Comparison Of Surfaces Of Fine and Coarse Grained Plier Jaws Etched In A 40 Per Cent Solution Of Nitric Acid x4. Fig. 4.—Comparison Of A Fine Grained Plier Handle And A Coarse Grained Jaw Surface Etched In A 40 Per Cent Solution Of Nitric Acid x2. Figs. 5 and 6—Photomicrographs Of Fine And Coarse Grained Pliers. x500.

immersed in this acid solution and allowed to remain there until a violent action takes place and brown fumes are liberated, after which the pieces are withdrawn, immediately washed in tap water, and the "scum" which collects on the etched surface wiped off. If some time elapses before these surfaces are examined, it may be advisable to give them a dip in an alkaline solution to neutralize the acid remaining on the surface after washing. It is not necessary to heat the acid solution to hasten the attack, because heat is generated by reaction as soon as the pieces are immersed. It is advisable to give the pieces a dip in boiling water after they are etched and wiped so that the surfaces will dry uniformly.

When all this has been done and the pieces examined it will be observed that some of the surfaces are dark and "mottled" and have the appearance of having been sprinkled with flakes of graphite, while other surfaces have a smooth dull gray appearance. The eye need not be trained to see this difference as there is almost as much contrast between them as there would be if one kind were black and the other white. Of course the question is, what does all this indicate? The answer is that it indicates that the pieces having dark "mottled" surfaces have been finished too hot in the forging, and the pieces with the dull gray surfaces have been forged at a temperature near the critical range. If one of the "mottled" pieces is fractured it will be found to have a "sash-weight iron" coarse fracture, but if one of the dull gray forgings is broken it will be found to be fine grained.

Figs. 2 and 3 show two plier jaws. Both of these jaws were etched in the nitric acid solution. Both were in the same bath and etched the same length of time. The jaw to the left is one of the dull gray variety. Subsequent breaking showed this jaw to be fine grained. The jaw to the right in Fig. 3 shows a "mottled" surface. Subsequent breaking showed this jaw to be very coarse grained. Fig. 4 shows the side view of a coarse grained jaw and a fine grained handle laid in juxtaposition for purpose of comparison. These were also etched in the nitric acid solution.

Fig. 5 shows a photomicrograph of the section of the fine grained plier jaw and Fig. 6 a photomicrograph of the section of the coarse grained plier jaw shown in Fig. 3. Both of these are magnified 500 times. Note the fine grain of the former with practically no cells and the coarse cellular structure of the latter.

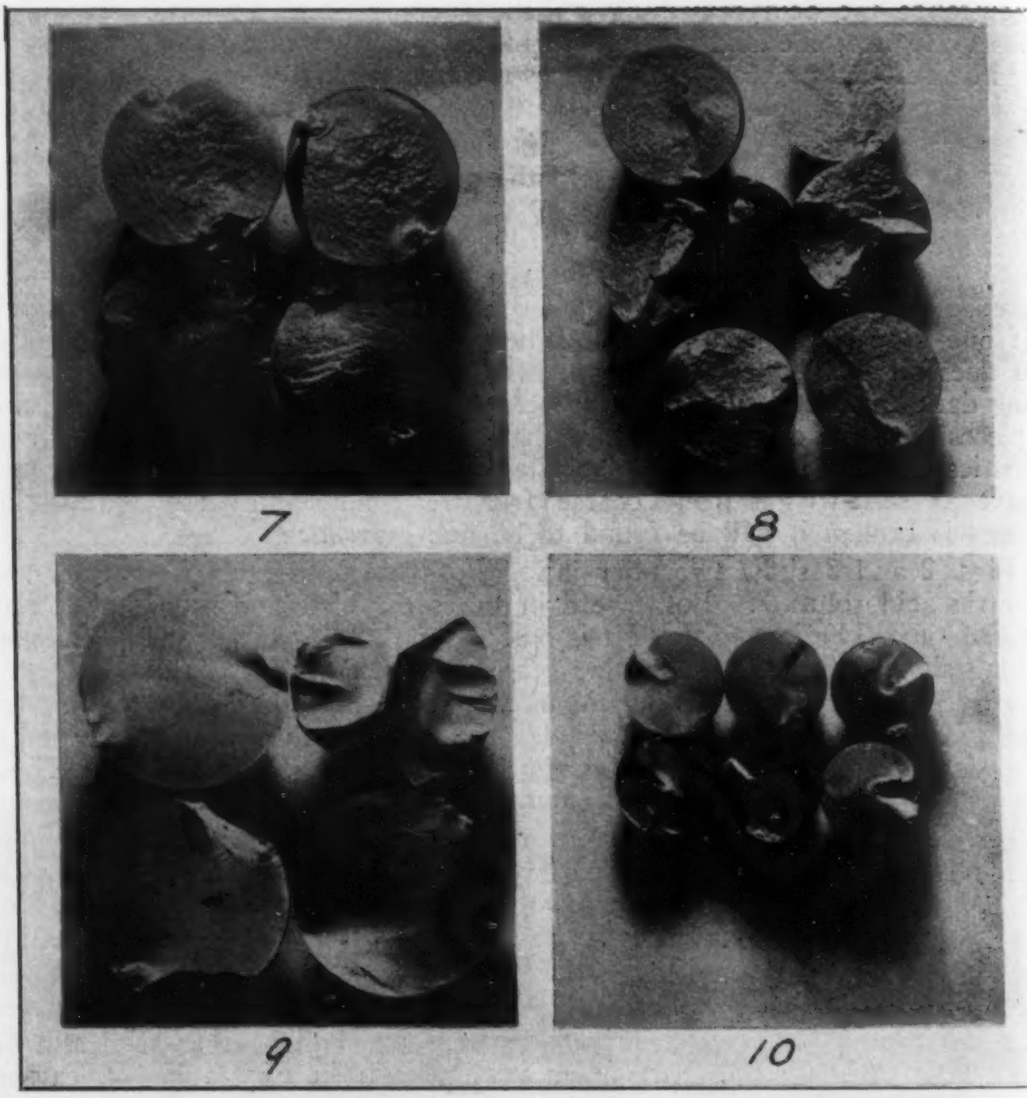
The writer has used this etching inspection successfully on 1.10 per cent carbon steel, on 1.00 per cent carbon, 1.50 chrome, ball bearing steel and on .80 per cent carbon steel. The plier jaws shown in Fig. 4 had a carbon content of .80 per cent.

Etching Test Easily Made

This etching test as a method of detecting coarse grain in forgings, is not a test which would necessarily have to be conducted in the laboratory or by the metallurgist. It is a thoroughly practical test which could be performed by the shop inspector or by the heat treating foreman. It requires little technique and little apparatus. It is not altogether impossible that this test could be made on every forging produced in the forge shop, as a part of production routine. In this event it would be necessary to have a tank of acid, a dipping basket impervious to acid, and an alkali bath. The entire production of forgings could then be etched and the "good" ones sorted from the "bad". The fact that the "good" forgings can be sorted from the

"bad" forgings by such a test does not warrant however a continuance of the use of a faulty forge furnace and faulty operations.

A better plan would be to first use the acid test on a certain percentage of the forgings as a means of investigating their condition, and then to correct



Figs. 7 and 8—Coarse Grained Fractures Of Balls Forged At Too High A Temperature. Figs. 9 and 10—Fine Grained Fractures Of Balls Forged At The Proper Temperature.

the forge furnace conditions and lower the forging and finishing temperatures. After this has been done, the acid test could be used very advantageously as a means of controlling or checking the forging operation.

Photographs in Figs. 7 to 10 show groups of fractured hardened steel balls. Figs. 7 and 8 show coarse dry fractures. Such balls are very brittle and have a low crushing strength. Photographs in Figs. 9 and 10 show fine grained velvety fractures.

The practice in most ball plants is to fracture balls selected at random from the batch just hardened, as a check on the hardening heat. It does not follow that when a basket or pan full of balls are thus inspected, after hardening, that every ball in the pan will be found to be coarse grained, like those balls shown in Figs. 7 and 8. Perhaps 20 to 40 percent of them are

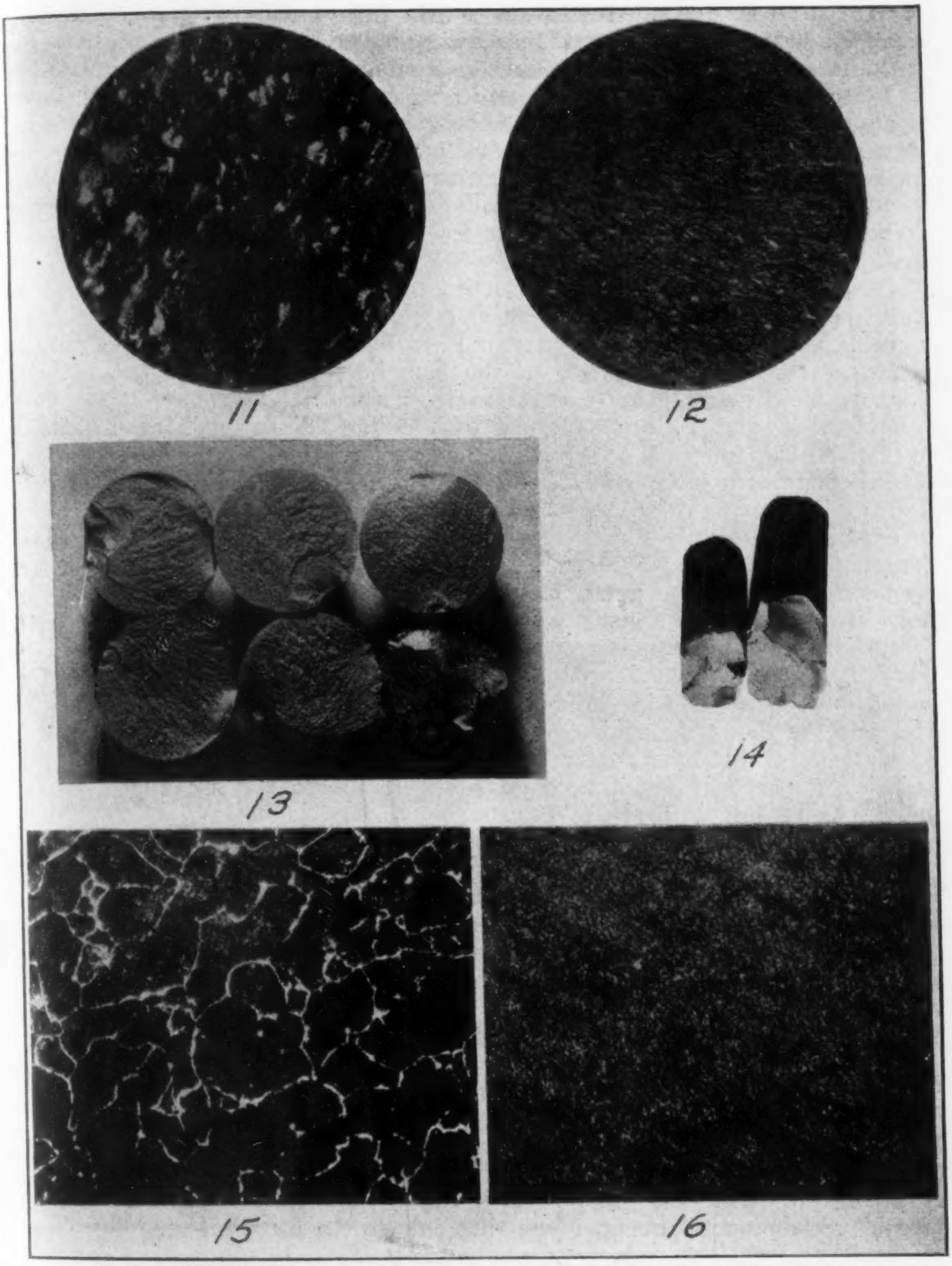


Fig. 11.—Fractures Of Balls Forged At Too High A Temperature. x50. Fig. 12.—Fractures Of Balls Forged At The Proper Temperature. x50. These Circles Represent Only A Portion Of The Broken Area Of The Balls. Fig. 13—Fractures Of Coarse Grained Balls Forged At Too High A Temperature. Fig. 14.—Two Of The Fractured Balls Shown In Fig. 13 After Rehammering To A Low Finishing Temperature. Fig. 15.—Typical Photomicrograph Of Overheated Balls, Fractures Of Which Are Shown In Fig. 13. x100. Fig. 16.—Photomicrograph Of The Properly Forged Pieces Shown In Fig. 14. x100.

coarse grained and the remainder fine grained and velvety, and the interesting part of it all is, that all this basket or pan full of balls were in the furnace together, heated together, and quenched together. It is hardly possible that such difference in fractures could be attributed to the lack of uniformity of heating in the chamber of the hardening furnace. A very thorough investigation in one of the ball plants definitely established the fact that the trouble started in the forge shop, and it was not until the forging equipment and methods were corrected, that the coarse grained fractures were eliminated.

With the forging shop continually overheating the steel, the hardening operation is usually nothing more or less than a futile attempt to put something into the steel which the forger has taken out.

Fig. 11 shows the natural fracture of a coarse grained ball such as shown in Figs. 7 and 8 magnified 50 times. Fig. 12 shows by comparison a fine grained ball such as shown in Figs. 9 and 10. These circles do not represent the outside diameter of the ball, but are simply portions of the fracture which were printed under a circular mat.

Figs. 13 and 14 illustrate one of the "freak" methods of reclaiming overheated ball forgings, of which we have previously spoken. Fig. 13 shows the fractures of a group of balls forged at a very high finishing temperature. Two of these balls were taken and reheated and reforged until the temperature was just slightly above the critical point and then hardened. These forged pieces are shown in Fig. 14. This shows that reworking at a low temperature will refine a coarse grained forging, but all this is interesting only from the metallurgist's point of view. It may be rightly called a "freak" method because it is not possible of commercial application. If a piece has already been forged and brought down to shape, to reforge it would merely mean to lay it in the cavities of the hammer dies and let the faces of the dies play against each other. The piece would not in reality be worked at all. The forger often becomes a steel manufacturer in that he takes a perfectly good piece of rolled steel, heats it up almost to the melting point, and in a sense "recasts" it into an "ingot" and nothing short of rerolling or rehammering will remove the ingotism or coarse grain.

Fig. 15 is a photomicrograph of one of the coarse grained balls shown in Fig. 13. Fig. 16 shows the micro-structure of the same ball after rehammering at a low temperature. Both of these photomicrographs were taken at 100 diameters magnification. There can be little question about the grain structure and relative strength of these two pieces.

Refining the Grain by Repeated Quenchings

D. K. Bullens[1] states, "when the initial structure shows a coarse grain size and overheating, the factors of diffusion and equalization become paramount, so that prolonged saturation, or repeated hardening must be used". He mentions a 10-inch diameter shaft having a coarse initial structure, requiring four quenchings to entirely sorbitize the steel, which is the same as saying "to refine the grain". This the writer classifies as only another "freak" reclaiming treatment, interesting only to the metallurgist.

Annealing and Normalizing

The purpose of annealing is to soften and put it in a machinable condition, and also to refine the grain. If a piece of steel has an initial structure of medium refinement, upon heating that piece above the critical point, and holding it there for a few hours and then cooling slowly, it is

[1] "Steel and Its Heat Treatment" by D. K. Bullins.

found that the maximum refinement has taken place. This form of heat treatment is called "annealing". In steel which is severely overheated and in a coarse grained condition, however, the old structure has a tendency to persist, even after prolonged annealing and slow cooling, and tends to lag behind and come back to its initial structure.

Fig. 17 shows a photomicrograph of the structure of a bar of very

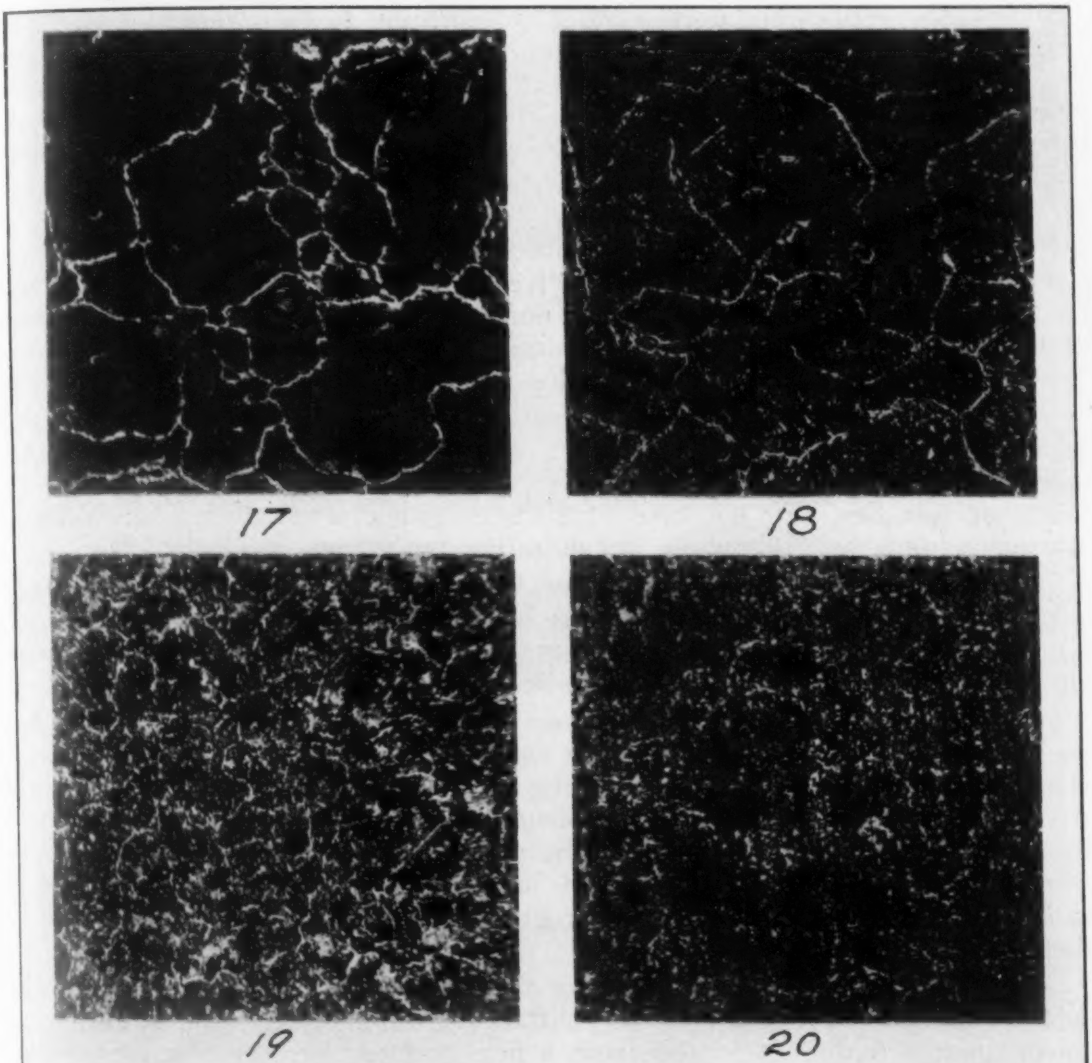


Fig. 17—Photomicrograph Of A Coarse Grained Hot Rolled Bar As Received From Mill. x150. Fig. 18—Photomicrograph Of The Same Bar After Annealing For 10 Hours At 1450 Degrees Fahr. x150. Fig. 19—Photomicrograph Of The Same Bar After Normalizing At 1650-1700 degrees Fahr. x150. Fig. 20—Photomicrograph Of A Fine Grained Hot Rolled Bar As Received From Mill. x150.

coarse grained steel as received from the steel mill when magnified 150 diameters. Fig. 18 at the same magnification shows the same piece of steel, but after a prolonged annealing just above the upper critical range followed by slow cooling. There is a tendency to form a new structure by this annealing, but also a tendency of the old structure to persist.

If, however, the piece is heated 250 to 300 degrees Fahr. higher than the upper critical point, held there for just a short time and then cooled in a free circulation of air, it will be found that the grain is partially refined.

This latter treatment is called "normalizing". Fig. 19 magnified 150 times shows the structure of the bar, after normalizing. This structure is much finer grained than either the "as received structure" or the "annealed structure", but the original coarse grain still tends to persist. This partial refinement of the grain by normalizing is due to the fact that the molecular changes take place more rapidly at the higher temperature and the tendency to lag is lessened, and owing to the fact that the normalized piece is cooled in air the molecules are prevented from returning to their initial state. This normalizing is usually followed by an anneal just above the critical point, the purpose of which is to soften it for machining operations. Fig. 20 shows the structure of a fine grained bar as received from the steel mills. While the normalized structure Fig. 19 is considerably finer than the "as received structure" Fig. 17, it is not as fine as the steel bar properly refined as shown in Fig. 20.

Normalizing is at best only a makeshift but comes nearer being a corrective treatment than any of the "freak" treatments previously described. A properly forged piece need not be normalized. A piece forged at too high a temperature can be only partly refined by normalizing. The fact that a piece can be normalized therefore does not justify faulty forging methods.

In the case of large forgings made on the steam drop or board drop hammer, or where the forged piece is of intricate shape, it is sometimes necessary to work at high temperatures in order to have the metal fill all parts of the dies. In the case of such forgings, it is always advisable to normalize and then follow by an annealing treatment.

In writing this paper the writer has principally in mind such forged articles as steel balls, pliers, scissors, cutlery, drills and the like, which are usually made on a helve or strap hammer. It is not improbable that some of the data will apply also on steam or board drop hammer work.

As previously stated Fig. 17 shows the structure of a coarse grained bar as received from the steel mill. The steel mills are not always exempt from the troubles arising from high forging or rolling temperatures. Of course the steel mill can bring about the structure shown in this photomicrograph by over-annealing as well. If the forging manufacturer forges this steel the initial structure as received will not have much effect, but if he buys so called annealed stock and it is coarse grained he will have endless trouble in the hardening room.

Fig. 21 shows a ball bearing ring from a coarse grained bar which was subjected to pressure. It bent very little and then broke. The bottom ring shown in this figure was made from a fine grained bar. It bent almost flat on itself and did not break. These rings have been etched in the 40 percent nitric acid solution and show respectively the mottled and dull gray surfaces. Fig. 22 shows the surfaces of these two rings as they came from the automatic machines. Note that the cutting tool has torn and glazed the surface of the ring from the coarse grained bar, while the surface of the fine grained ring has been machined with a clean even cut. One need have little imagination to conceive of what happens to the tools when these coarse grained rings are machined.

These photographs are interesting in that they illustrate the brittleness and hardness of coarse grained structures as compared with fine grained structures. These coarse grained structures are caused by a segregation of cementite. Cementite is the hardest constituent in steel. H. M. Howe[2]

2. "The Metallography Of Steel And Cast Iron" by H. M. Howe.

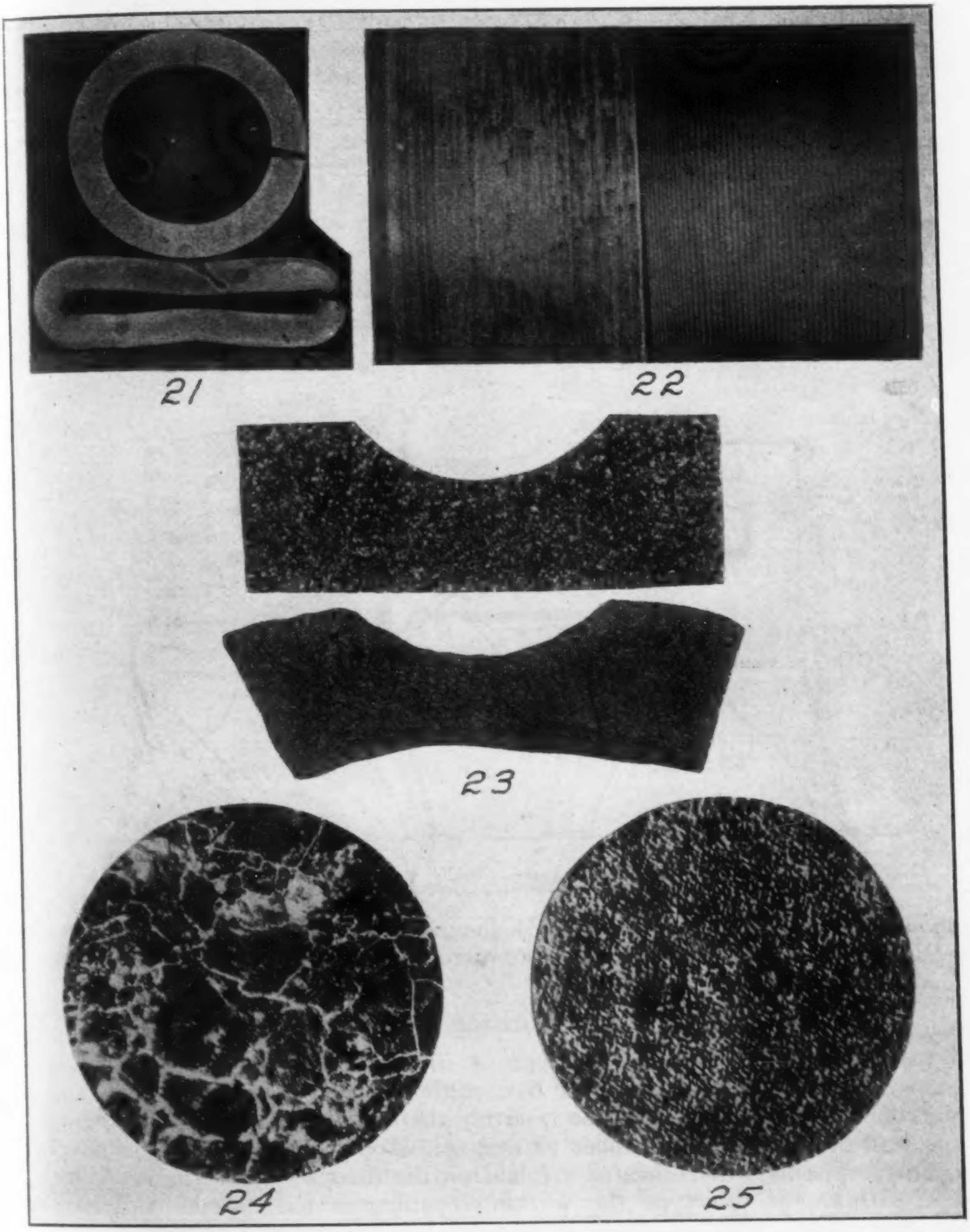


Fig. 21—Ball Bearing Rings. The Upper Ring Was Made From A Coarse Grained Bar And The Flattened Ring Was Made From A Fine Grained Bar. Upon Flattening The Upper Ring It Bent Very Little Before It Broke. Fig. 22—Photograph Of The Surface Of The Rings Shown In Fig. 21 Showing How The Turning Tool Tears And Glazes Over On The Coarse Grained Bar While The Fine Grained Bar Machines With A Smooth Even Cut. Fig. 23—The Upper Section Is That Of A Coarse Grained Fracture Of A Ball Ring While The Lower Section Is That Rings Respectively Of Fig. 21 x 100. The Two Black Bands On The Right Side Of The Rings In Fig. 21 Are Cords Which Carried Identification Tags And Are Not Cracks.

states "it is harder than glass and nearly as brittle". This may account for the fact that one of the drill manufacturers finds that a coarse grained steel with a Brinell hardness of 200 is more difficult to machine than fine grained steel with a Brinell hardness of 225.

Fig. 23 shows the natural fracture of the coarse and fine grained rings

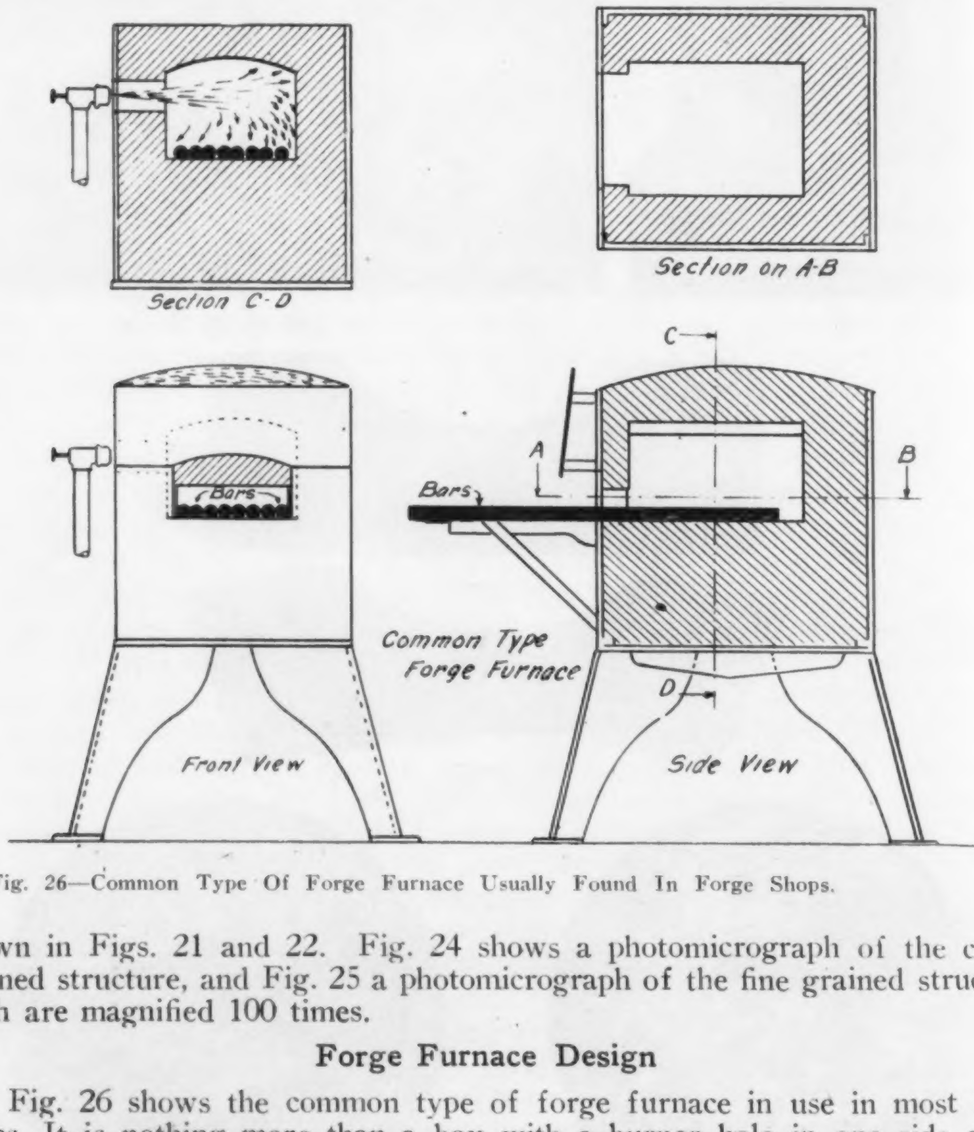


Fig. 26—Common Type Of Forge Furnace Usually Found In Forge Shops.

shown in Figs. 21 and 22. Fig. 24 shows a photomicrograph of the coarse grained structure, and Fig. 25 a photomicrograph of the fine grained structure. Both are magnified 100 times.

Forge Furnace Design

Fig. 26 shows the common type of forge furnace in use in most forge shops. It is nothing more than a box with a burner hole in one side and a working opening in the front for inserting the bars. The burner plays against one wall of the heating chamber as that is the only baffle wall it has to play against. The bars to be heated are laid on the floor of the furnace. Usually in a furnace of this type the working opening is too narrow and carries too few bars.

Let us assume that the furnace shown in Fig. 26 carries 8 bars of steel bar stock as shown. Let us further assume that the entire forging operation, from the time the bar is taken from the forge furnace, finished under the hammer, and returned to the forge furnace, consumes one minute. It would then require 8 minutes to make forgings of each bar in the furnace and return again to bar 1. The temperature of the bar when it is returned to the forge furnace, after the forging operation, would probably be 1000 or 1200 degrees

Fahr., and possibly only heated for a few inches of length to this temperature.

All of this shows that the bars must be raised from a temperature of 1000 degrees Fahr. to a forging temperature of say 1800 or 1900 degrees Fahr. in 8 minutes, which is a very rapid rate of heating and the only way to accomplish this rapid rate is to have a super-heated heating chamber. When working under such conditions, suppose that the hammer man is a little

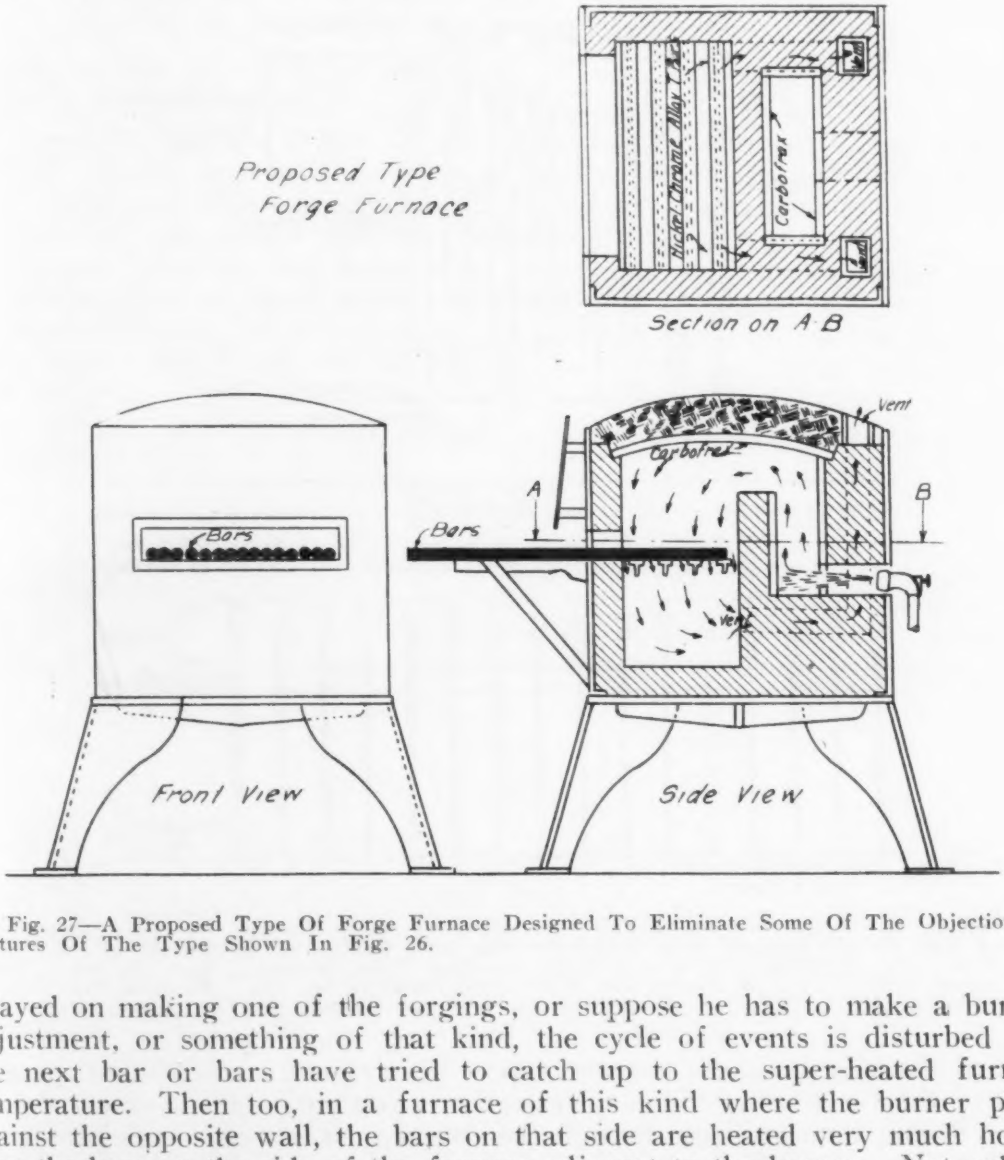


Fig. 27—A Proposed Type Of Forge Furnace Designed To Eliminate Some Of The Objectionable Features Of The Type Shown In Fig. 26.

delayed on making one of the forgings, or suppose he has to make a burner adjustment, or something of that kind, the cycle of events is disturbed and the next bar or bars have tried to catch up to the super-heated furnace temperature. Then too, in a furnace of this kind where the burner plays against the opposite wall, the bars on that side are heated very much hotter than the bars on the side of the furnace adjacent to the burner. Not only is such a furnace inducive to high heats, but it is also inducive to very un-uniform high heats. The furnace as shown is not the worst type of forge furnace in use, but it is the common type to be found in many forge shops.

Fig. 27 shows a proposed type of forge furnace, designed to eliminate some of the objectionable features of the furnace shown in Fig. 26. The writer has designed and built several furnaces of this type and the operation of them was satisfactory, although he does not make the claim that this is the only type of furnace that will overcome the objectionable features, as there are many other ways of making furnaces with baffle walls, combustion chambers, vents and what not. Also no claim could be made as to the

efficiency of this furnace, so far as fuel consumption is concerned. It would probably burn more oil than the common type of furnace, but it would surely burn less "steel." The furnace shown in this figure consists of a combustion chamber and a heating or working chamber. The baffle wall shown, runs across the entire width of the furnace. The bars to be heated project into the middle of the heating chamber, rather than lying on the floor of the

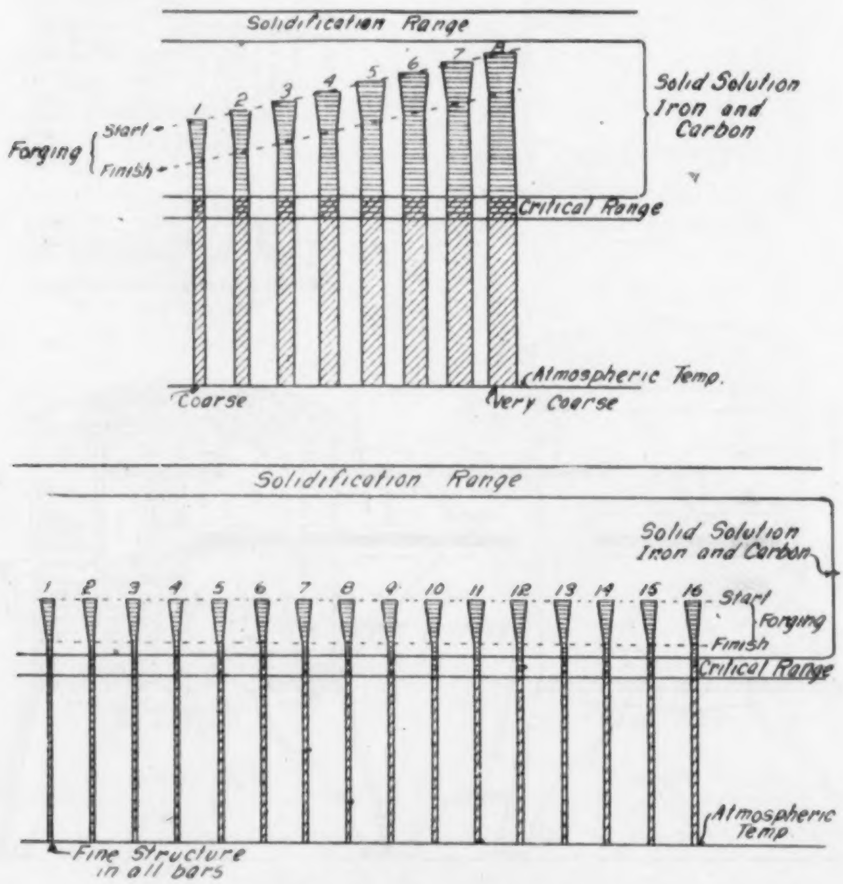


Fig. 28—The Upper Portion Of This Diagram Shows What Happens To The 8 Nonuniformly Heated Bars In The Common Type Forge Furnace, After Conducting Forging At A High Finishing Heat. The Resulting Fractures Can Be Anything From Medium Coarse To Very Coarse. The Lower Half Of Fig. 28 Shows The More Ideal Condition Of Grain Structure Which Would Result When Heating Twice As Many Bars In A Forge Furnace Of The Proper Design.

heating chamber as in the common type. Several vents are built in the back wall of the forge to provide an escape for waste gases and to direct the hot gases during their passage through the furnace. The result is a passage of the hot gases through the bars and a very uniform heating chamber results, by reason of combustion having taken place in a separate chamber. To provide for the stub ends of bars a grid of a heat resisting alloy or refractory is provided as shown. Note that this furnace has a working opening which will permit of the heating of 16 bars. It would therefore require 16 minutes to make a forging from all bars in the furnace, as against 8 minutes in the type as shown in Fig. 28. This allows more time for heating each bar and the heating chamber can be kept down to a temperature more nearly like the working temperature .

If the same delays in the forging operations occur, it will not do the bars any harm to soak for a short time. In fact a soak for a relatively long

period of time in this furnace would not do as much harm to the steel as a short period of heating at high temperature in the common type forge.

The width of a furnace working opening should be designed with respect to:

a. Length of time required to make a forging
b. The diameter of stock used
c. The temperature of the heating chamber.

The writer has in mind a furnace of this type which was built for heating bars for a "bulldozer". This furnace was 12 feet long with a baffle wall running the entire length of the furnace and 3 oil burners provided at the back. Every part of this heating chamber was uniform in temperature and it was almost impossible to "burn" the bars, but always possible to obtain sufficient heat for proper forging conditions.

Fig. 28, upper portion shows what happens to the 8 un-uniformly heated bars in the common forge, after conducting the forging at a high finishing temperature. The resulting fractures can be anything from medium coarse to very coarse. The lower half of Fig. 28 shows the more ideal condition of grain structure, which would result when heating twice as many bars in a forge furnace of the proper design. These diagrams need no further explanation.

Conclusion

In conclusion the writer wishes to emphasize that the question of proper forging has been neglected too long and it is high time that we give the same consideration to the forging furnace equipment and methods of operation, as we give to the annealing and hardening equipment and operation.

COMBUSTION AS IT PERTAINS TO INDUSTRIAL HEAT TREATMENT FURNACES

By A. D. Frydendall

Abstract

This paper treats with the subject of combustion as it pertains to industrial heating of materials. The author having had many years' experience in the design and operation of industrial heating furnaces has handled the subject from both a practical and theoretical standpoint discussing in some detail those points which are of prime importance in the efficient combustion of fuels.

He discusses flames, both luminous and nonluminous, as they are met with in the use of the common fuel gases.

The various types of fuels which are commonly met with and used in industrial heating are treated in considerable detail and the author has pointed out the advantages and disadvantages in the use of the various types.

In conclusion he brings out those points which are of prime importance in the efficient operation and handling of fuels in heating materials. These points include furnace design, burner design and burner operation, pointing out that the burners should be of such design and operation as to insure the intimate mixture of fuel and air so that only that amount of fuel that can be completely burned in the furnace chamber should be allowed to pass the burners. The furnaces should be correctly proportioned for the work they are to perform. Through the knowledge of the laws of combustion any furnace operator could obtain a substantial saving in fuel consumption.

THE subject of combustion, as it pertains to industrial furnaces, is not generally being given the consideration to which it is entitled. In the boiler room of a plant the subject is a familiar one, and the importance of it is emphasized by the many devices seen in the modern boiler room to assist those in charge in maintaining the correct conditions for high efficiency.

If you will step into the heat-treating room or forge shop of that same concern, you will find operators trying to maintain accurate temperatures and correct atmospheric conditions in furnaces where hundreds of dollars worth of material is heat treated every day, with nothing to guide them in their work but the colored lights of the pyrometer system. It is a common sight to see furnaces equipped with shutters and dampers for controlling the combustion, only to find that the operator does not know how to use them and does not care enough to learn. There are few furnaces today which, when properly operated would not show a neat saving in fuel and refractories when totalled up for a year's operation.

A thorough knowledge of the science of combustion is not necessary to insure practical success, but other things being equal, the man who has mastered the principles of combustion and applies them in his daily work, has a greater chance of making a success in his chosen field

A paper presented before a meeting of the society. The author, A. D. Frydendall, is associated with the Peoples Gas Co., Chicago, Ill.

than does the man who neglects the theoretical side of his education. A knowledge of both the practical and theoretical side is necessary for a well rounded education, and theory modified to conform with practice, is a big assistance to any man. It is not the purpose of this paper to go deeply into the theory of combustion, or to give a table showing the physical properties of the various fuels, but rather to outline the fundamental principles involved. Any discussion of combustion must be somewhat technical, but an effort will be made to treat the matter as simply as possible.

Combustion Defined

For our purpose, combustion may be defined as the chemical union of two substances taking place with sufficient energy to develop heat. In order that this chemical reaction may take place, it is necessary for the substances entering into the combustion to be above their combining or ignition point.

The most common substances used for fuel are complex compounds consisting mostly of carbon and hydrogen, with small amounts of sulphur, oxygen and nitrogen. Other constituents may be present, but they may be neglected without interfering with the principles under discussion or their practical application. These compounds of carbon and hydrogen may be used in either the solid, liquid or gaseous form, but no matter what form is used, they are governed by the same general principles.

These fuels unite with oxygen to produce the effect of heat as laid down in our definition. Oxygen abounds in the air where it is mixed with nitrogen in the proportions of 21 volumes of oxygen to 79 volumes of nitrogen. It is the oxygen of the air that supports combustion—the nitrogen serving no good purpose, in fact it is a detriment, as it reduces flame temperatures and necessitates larger flues and equipment to handle it.

Flames

To the average mind combustion suggests flame. Flame is a gaseous mass in the process of combustion. The condition necessary for flaming is that both substances entering into combustion be in the gaseous or vapor state. In the combustion of solid or liquid fuels where flame exists, it is caused by the gaseous products which are distilled from the solid matter, or produced by chemical action, entering into combination with air, thus producing flame. Flames may be classified as luminous and nonluminous and short and long. As examples of luminous flames, we might cite any of the hydrocarbons such as bituminous coal oil and acetylene.

Luminous and Nonluminous Flames

Nonluminous flames are met with when dealing with the common gases such as artificial gas, producer gas, water gas, hydrogen and natural gas. As a rule a nonluminous flame is harder to control than is a luminous flame, because the operator cannot see the flame, as is the case when working with luminous flames.

Luminosity in flames may be ascribed to three causes;

1. The temperature of the flame
2. The density of the gases composing the flame
3. The introduction of solid matter into the flame.

The effect of flame temperature and luminosity may be observed by holding a gas jet in contact with a cold plate and noting its diminished luminosity; on the other hand, if the gas and air are strongly heated before combustion takes place, the luminosity is greatly increased. There are exceptions to this rule, and the most common one is the hydrogen flame. Since combustion in furnace problems is always carried on at atmospheric pressure, the second cause of luminosity, namely, the density of the common gases composing the flame may be neglected. The third cause of luminosity may best be illustrated by the familiar gas light in which a mantle consisting of metallic oxides is raised to incandescence by introducing it into a nonluminous Bunsen flame.

The combustion of a liquid hydrocarbon, such as oil, is exceedingly complicated, and the decompositions which are peculiar to this fuel not only give off dense vapors which become incandescent, but also precipitates carbon, which by the combustion, adds to the luminosity of the flame. Since the luminosity of a flame is dependent on the temperature, it is possible to judge roughly the flame temperature by the flame color. Closely associated with luminosity is transparency, and it may be said that nonluminous flames are transparent flames, while luminous flames are opaque.

Flames may be either long or short, depending upon the rate of fuel consumption, the affinity of the fuel for oxygen, and the thorough mixing of the fuel and air. As a rule, long flames are low temperature flames and are the result of an improper mixture of fuel and air. Short flames on the other hand, are the result of a thorough mixture of the fuel and air, and are high temperature flames. From this it follows that short, high temperature flames indicate good combustive conditions.

Heat of Combustion

The other idea associated with combustion is heat, and that is the important thing in industrial furnace operation. The amount of heat developed in the combustion of any particular fuel measured in B.t.u's. is dependent upon heat of combustion of the fuel and the final products formed. The total amount of heat developed by the burning of any fuel is independent of the speed of combustion, and is the same, provided always the same final products are formed. As an example—let us take one pound of carbon which is completely burned to carbon dioxide—then 14,500 B.t.u.'s will be liberated. This pound of carbon may be consumed in one hour or in ten minutes, but in each case the heat liberated is the same. If, however, combustion is incomplete and carbon monoxide is formed, then only 4380 B.t.u.'s, or one-third of the total heat of the fuel, will be produced—the remaining 10,120 B.t.u.'s or two-thirds, will be liberated when the CO is consumed. This shows the necessity for complete combustion if we are to utilize the entire heat of the fuel.

Of equal importance to the heat developed is the temperature attained, or as it is more commonly called, the flame temperature. This depends upon several things, namely: The B.t.u. value of the fuel, the final products formed and the rapidity with which combustion takes place. Theoretically, it is assumed that combustion is instantaneous and complete, that there are no radiation losses, from the boundary

walls, that there is no dissociation, that the inert gases do not enter into the reaction, and that all of the heat of the fuel is used to raise the temperature of the products of combustion. Theoretical flame temperatures are never realized in practice, but are useful in determining the suitability of a fuel for any given operation. As an example, a producer gas showing the following composition:

Hydrogen	10 per cent
Methane	3 per cent
Acetylene	5 per cent
Carbon Monoxide	23 per cent
Oxygen	5 per cent
Carbon Dioxide	5 per cent

when burned with cold air has a theoretical flame temperature of 2832 degrees Fahr. which is reduced by certain factors in practice to about 2000 degrees Fahr. This temperature is insufficient to melt steel, and any attempt to use it in that manner would meet with failure as temperatures exceeding 3000 degrees Fahr. are required. Producer gas, however, when properly assisted by preheating both gas and air is being used daily for that purpose.

In practice, theoretical flame temperatures are reduced because combustion is not instantaneous—the walls of the furnace also absorb heat, and combustion is either not complete or else is accompanied with an excess of air, and air in excess of that required for combustion means low flame temperatures and high flue gas losses. From the foregoing, it would seem that any device which would permit an intimate mixture of the fuel and air in controllable quantities would function properly, but the great variety of stokers, oil burners and gas burners on the market are evidence that such conditions are not easily accomplished.

Specific Fuels

Passing on to specific fuels, we will apply our principles in turn to solid, liquid and gaseous fuels dwelling particularly on liquid fuel as there are several points possessed by it not common to the other fuels, as well as those common to all fuels.

Coke and Anthracite Coal

With solid substances for fuel, which are nearly pure carbon, such as coke or anthracite coal, these rules are easily applied, as each carbon atom is held in place until it has received the necessary two atoms of oxygen for combustion, after which it passes off as carbon dioxide. Were it not for the possible formation of carbon monoxide no greater space than that necessary to contain the fuel would be required for complete combustion. The concentrated heat of coke is made use of in the blast furnace and cupola where intense heat is wanted in small space.

Bituminous Coal

As we pass on to bituminous coal, a combination of carbon and hydrocarbon, the combustion becomes more difficult owing to the liberation of gases, which necessitates careful handling to insure complete and smokeless combustion. Owing to the gases set free, the combustion chamber must be larger than required for coke, to permit complete combustion within the chamber. The heat is not as concentrated as that of coke and for this reason coal is used in heating puddling and

metallurgical furnaces where a more general application of heat is desired than in the cupola or blast furnace.

The reactions going on in the fuel bed of a coal or coke-fired furnace deserve some consideration, especially as coal is the most generally used fuel. The fuel bed of the average coal-fired furnace may be divided into three active zones, in each of which a combustion reaction is going on. In the first or oxidizing zone, the oxygen of the air combines with the carbon in the fuel, and is converted into carbon dioxide in accordance with the chemical equations.

$$C + O_2 = CO_2$$

The depth of the oxidizing zone varies with the thickness of fuel bed; for a six-inch fuel bed and bituminous coal, it is about two or three inches. The carbon dioxide content in the oxidizing zone reaches a maximum of 12 to 18 per cent. In this zone the maximum temperature of 2200 to 2700 degrees Fahr. is also reached at a height corresponding to the maximum CO_2 content of the gas.

The second zone is the reduction zone, and it is in this zone that the CO_2 is reduced to CO. The reducing zone extends from the oxidizing zone to the top of the fuel bed. The amount of reduction varies with the temperature and the time of contact between the CO_2 and the hot carbon, the limiting feature being the temperature of the fuel bed.

The last or distillation zone, consists mostly of fresh fuel from which the volatile matter is being driven off by the heat. It is in this zone that hydrogen, methane, tar, soot and other hydrocarbons are liberated. This action is independent of the air passing into the furnace, and is similar in action to the destructive distillation of coal in gas retorts.

The percentage of combustible in the gases in the fuel bed increase steadily above the oxidation zone until at the surface of the fuel, a maximum of 15 to 30 per cent combustible gas and no free oxygen is shown. If no additional air is supplied above the fire, this combustible passes out of the stack unconsumed and it is for this reason that additional air for complete combustion must be added over the fire. In practice the fuel bed is seldom even, and additional air for combustion is furnished by holes and thin spots in the fire and leakage around doors and in the setting. This leakage is enough, in some cases, to furnish excess air over that required for combustion, thereby adding to the heat loss. The fuel bed of any coal-fired furnace is essentially a gas producer, and should be treated as such when considering the process of combustion.

Oil Fuel

Oil, as a fuel, is one of the most difficult to burn satisfactorily with good economy. Oil in bulk has little surface, and before it can be burned successfully, it is necessary to stretch or increase its surface enormously to permit the required number of oxygen atoms to come in contact with it to produce complete combustion. This increase in surface may be brought about in several ways, but the ones most in use are spraying, either with a steam or air jet, or by mechanical means.

At the very first we are met with difficulties, as the particles of

oil produced by the atomizing agent when freed from the force of gravity and under the force known as surface tension, assume the shape of a sphere which affords the least surface possible for the impact of oxygen atoms of any solid. To further complicate matters, these tiny spheres of oil are traveling at a high velocity towards the vent or stack. We see, therefore, that it is either necessary to provide a larger chamber or permit sufficient time for each atom of oil to reach the required amount of oxygen, or introduce means of hastening the mixture of oil and air to complete combustion within the furnace chamber. The speed of mixing may be increased:

First—By correct design of burner to more thoroughly atomize the oil.

Second—By introducing eddies in the fuel and the air stream.

Third—By initial heating of the air to increase the speed of diffusion.

There is one other action going on simultaneously with those already mentioned, that is, decomposition of the oil fuel.

The first effect of the heat is to dissociate the hydrogen from the carbon. It is these products of the decomposition of the oil, rather than the oil itself, that burn and produce the flame characteristic of oil fuel. The luminous part of the flame is caused by the white hot particles of carbon freed from their hydrogen components, and which have not yet reached the necessary air for combustion. If the temperature of these hot gases is kept above the point of ignition, until all the dissociated carbon is consumed, smokeless combustion is obtained. If, however, their temperature falls below the ignition point, smoke results. For this reason, fire brick walls and arches, when hot, assist in perfecting complete combustion.

Dissociation of the oil also manifests itself in another way. If raw oil is deposited on a hot surface, the liquid oil is decomposed, giving up gas and leaving as a residue, carbon in the form of coke. This coke is very hard and sometimes requires the use of cold chisel and hammer to remove and when thrown into a fire is consumed very slowly. It is for this reason that attempts to convert the oil into a gas before burning, have resulted mostly in failures, due to the retorts filling up with coke. This condition often develops in furnace practice due to the raw oil striking some portion of the heated brick work which decomposes the oil and deposits carbon.

In order that the high temperatures may be obtained, it is necessary that large quantities of fuel be consumed in a small space, and this requires a short flame. Conditions which assist in obtaining short flames are:

Pure carbon fuel
Intimate mixture of fuel and air to reduce time of diffusion
Preheating of air to increase rapidity of diffusion
Large fuel surface exposed to oxygen.

These rules are general and apply to any form of fuel. In addition to these we may consider a few others of special importance in the use of fuel oil:

a.—The volume of combustion chamber must be large—larger than for any other fuel

b.—The fuel must be exposed to the heat of the furnace in such

form that the largest possible surface is presented for vaporization of the oil and the impact of oxygen atoms

c.—The oil must spray freely into the furnace and burn without touching any portion of hot brick-work in its liquid form, as such would cause carbon deposits.

Gaseous Fuel

Turning now to gaseous fuel, and applying the principles as previously laid down, we find no problems such as found in the burning of oil fuel. Gas to start out with, is a stable substance and can be subjected to any conditions found in the heat-treating and forging furnaces without encountering any difficulties. As usually used, it is at atmospheric temperatures, and at pressures varying from two to six inches of water column.

In the burning of gas no matter whether lean producer gas or the rich natural gas, the main thing to be sought is an intimate mixture of the gas and air. Compared to oil this is easy, as we are dealing with comparatively large volumes and these large volumes can be regulated with a small percentage of error. The average gas flame is nonluminous and because of that fact requires closer observation to maintain the desired atmospheric conditions. Owing to the good mixture of fuel and air usually obtained with gaseous fuel, the flame of burning gas is short and combustion chambers need not be as large as is required for oil fuel. This advantage of short flames is also used in several so-called heating machines for continuous production where concentration of heat is desired.

Passing on to the application, or rather the lack of applications of these few simple principles of combustion to industrial furnaces, let us see where possible fuel savings may be made. One of the greatest losses in the operation of the average furnace is the flue-gas loss in excess air. The extent of this loss will vary with different fuels—it is largest with coal and least with gas, the loss being greater at high temperatures, decreasing as the working temperature decreases. A concrete example will better illustrate the point. Let us take an oil of the following analysis:

Carbon	84.0 per cent
Hydrogen	12.7 per cent
Oxygen	1.2 per cent
Sulphur	0.4 per cent
Nitrogen	1.7 per cent

For perfect combustion this will require 14.03 pounds of air per pound of oil, and at 1500 degrees Fahr. the heat carried away per pound of oil, by the products of perfect combustion is approximately 6250 B.t.u.'s. If now, instead of 14.03 pounds of air, an excess of 30 per cent is used, or a total of 18.23 pounds, then the flue-gas loss is 7840 B.t.u.'s, or an increase of 1590 B.t.u.'s, due to excess air. Suppose now the temperatures of the flue-gases leaving the furnace is 2200 degrees Fahr. such as might be the case in a forging furnace—then the loss per pound of oil with perfect combustion is 9630 B.t.u.'s, or an increase of 3380 B.t.u.'s, due to an increase in flue-gas temperature. If we assume, as before, that 30 per cent excess air is actually used, then the flue-gas loss at 2200 degrees Fahr. would be 12,000 B.t.u.'s, or an increase of 2380 B.t.u.'s due to excess air. This figure of 30 per cent excess air is

not high and there are a great many furnaces in operation where the excess air exceeds that amount.

Aside from the direct flue-gas loss, excess air manifests itself in other ways. Where excess air is used, the flame is sharp and cutting, and often causes a localized heat or blow-pipe action which forces the temperature of the refractories up to a point resulting in short life and increased maintenance.

Excess air also has a bad effect upon the material being heated. It produces scale on the carburizing boxes and shortens their life. If the material being heated is for drop-forging, the result of scale is shown in the shortened life of the dies. This evil of excess air is one of the most common, and there are few shops using industrial furnaces where the evil does not exist.

There are several ratio valves and mixers on the market which are intended to produce and maintain a constant ratio between the fuel and combustion air. The principles upon which these operate vary. One consists of a mechanical connection between the air and gas valve, so constructed that the two valves are operated simultaneously, and in the correct amount, to assure a properly proportioned mixture. To assure an intimate mixture of both fuel and air, they are passed through a small blower which forces the mixture to the furnace.

The other consists of a stream of high pressure gas which is forced through a venturi tube, and which draws in a sufficient volume of air for combustion. This apparatus is, within reason, automatic, as any increase in the flow of gas will cause a corresponding increase in the air. Devices of this nature are evidence that much attention is being paid to insure the proper combustive condition in the furnace with the resulting gain in fuel economy.

One other loss which can be seen nearly every day—is the tendency on the part of the operator to force the furnace when bringing up the heat. Forge furnaces are operated with great sheets of flame rising from the working opening; whereas, if the furnace had been operated with the chamber filled with flame, and only the amount of oil being used that could be entirely consumed within the chamber, the fuel consumption would have been reduced considerably.

It sometimes happens that the excess flame cannot be eliminated without sacrificing the furnace output. This is due to the burners not functioning properly. It was pointed out in the first part of this paper, that to produce high temeratures, it was necessary to burn large quantities of fuel in a small space, and to do this, a thorough mixture of the fuel and air was required. A poor mixture means long flames and long flames mean low temperatures, which in turn reduces output. The improvement in furnace operation—resulting from the use of proper burners, is due to the better mixture obtained, which reacts all along the line until the final result of increased output, or lower fuel consumption, is obtained.

While on the subject of forge furnaces, it should be mentioned that a great many in use today are too small for the work they are doing. It is poor economy to put in a small furnace and then force it to its limit for production. As a result of this practice excessive flue-gas temperatures occur together with their resulting high heat losses, excessive

refractory costs and a possible production loss due to furnace roofs failing without warning. The additional money spent for a furnace that can handle the job easily, will be returned many times in the form of lower fuel costs, increased production, and better heated stock.

Heat-treating furnaces with a plume of burning gas six inches high, rising from the vents, are no unusual occurrence. This is due to the desire of the operator to maintain a reducing atmosphere, and as an indicator, it is a sure thing, but it could have been reduced to a flame an inch long without sacrificing its efficiency as an indicator, or interfering with atmospheric conditions in the furnace.

In the average heat-treating furnace, operating at 1600 degrees Fahr. flue gases carry away nearly 30 per cent of the useful heat of the fuel. A great deal of this heat can be recovered by recuperation. With a temperature of 1600 degrees Fahr. in the chamber, a saving of 20 per cent in fuel has been shown, and as the temperature of the working chamber rises, the flue-gas losses increase and at 2400 degrees Fahr. 31.3 per cent of the heat of the fuel has been recovered and returned to the furnace.

Recuperation

The principle of recuperation consists of passing the hot flue gases after leaving the furnace over a pipe coil, or air chamber, containing the necessary air for combustion. In passing over the recuperator, as it is called, the waste gases give up their heat to the contained air which is used for combustion. This heated combustion air returns to the furnace the heat recovered from the flue-gas with the result that less fuel is required to maintain the desired temperature. The flame temperature with preheated air is also higher than when using cold combustion air, and this higher flame temperature increases the output of the furnace.

Conclusion

In summing up the foregoing it may be said that to insure low fuel consumption, a furnace should be operated with the least excess air possible and in the case of reducing atmospheres, no more fuel than that necessary to produce the desired conditions should be used. The burners should be of such design and operation as to insure an intimate mixture of the fuel and the air. Only that amount of fuel that can be completely burned within the furnace chamber should be allowed to pass the burners and the furnaces should be correctly proportioned for the work they are to perform. These conditions are direct and within the power of any operator to rectify. There are also other losses such as losses due to moisture in the fuel and to the moisture formed during combustion, as well as that which is in the air but which cannot be controlled by the operator. These points have been left out of the discussion.

The day is rapidly approaching when combustion in the forge shop and heat-treating room will be given the same consideration that it now receives in the boiler room.

A knowledge of the laws of combustion, and their application, as herein outlined will afford means whereby any furnace operator can show a substantial saving in fuel consumption.

TESTS SHOWING THE EFFECT OF HIGH TEMPERATURES IN MALLEABLE IRON

By T. D. Lynch and W. J. Merten

Abstract

This paper presents the result of numerous tests made upon malleable iron castings after they have been subjected to various high temperatures. The susceptibility of structural changes of malleable iron when subjected to various elevated temperatures is shown. The tests indicated a wide variation in critical temperatures of different samples of malleable which were tested.

The authors recommend the use of high annealing temperatures from 900 to 925 degrees Cent. (1652-1697 degrees Fahr.) for malleablizing when it is desired to obtain high quality of material with a high degree of ductility from annealing charges representng different chemical analyses. These tests also demonstrated the fact that it was possible to reheat malleable iron to the proper temperature without destroying its malleablized structure, however, too high a temperature will re-establish white, hard and brittle structure. Accelerated cooling appears to be conducive to finer grained ferrite and therefore a tougher and more ductile material.

MALLEABLE iron and its susceptibility to structural changes at various elevated temperatures has been investigated during recent months in connection with:

1st—Galvanizing, sherardizing and other surface protection processes where the maximum temperature does not exceed the visible red range, 480 degrees Cent.

2nd—Heating for the purpose of annealing mottled and white castings.

3rd—Heating for the purpose of straightening warped castings.

The changes occurring during galvanizing, sherardizing, and other surface protection processes have been described quite adequately by others and will not be discussed here.

In the heating for the purpose of annealing mottled and white castings, we approach the problem from the negative side. Here temperature is applied for the express purpose of changing the internal structures of the metals which are unfitted for commercial use.

Malleable iron consumers are frequently confronted with the fact that at the time of machining for assembling hard (white or mottled structure) castings are encountered and must either be reclaimed or delay production. An investigation was carried on to determine the advisability of malleablizing castings received in a hard and brittle condition, should the necessity demand such a procedure, instead of scrapping the castings and entering a replacement order.

A problem presented itself in the form of a malleable iron blower fan casting, Fig. 1, which was found to be so hard and brittle that a small deformation and light hammering caused it to break into fragments. Pieces of one of these castings were selected and the full hub part and one-half

A paper presented before a meeting of the society. The authors, T. D. Lynch and W. J. Merten are associated with the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

of the rim were imbedded in iron scale (Fe_3O_4), and heated, in a gas fired furnace to a temperature of about 870 degrees Cent. for about ten hours, and then gradually cooled to about 700 degrees Cent. over a period of 30 hours, or a total period of 40 hours. The pieces were then taken from the furnace and cooled in air.

The rim part of the casting, Fig. 2, was bent through an angle of

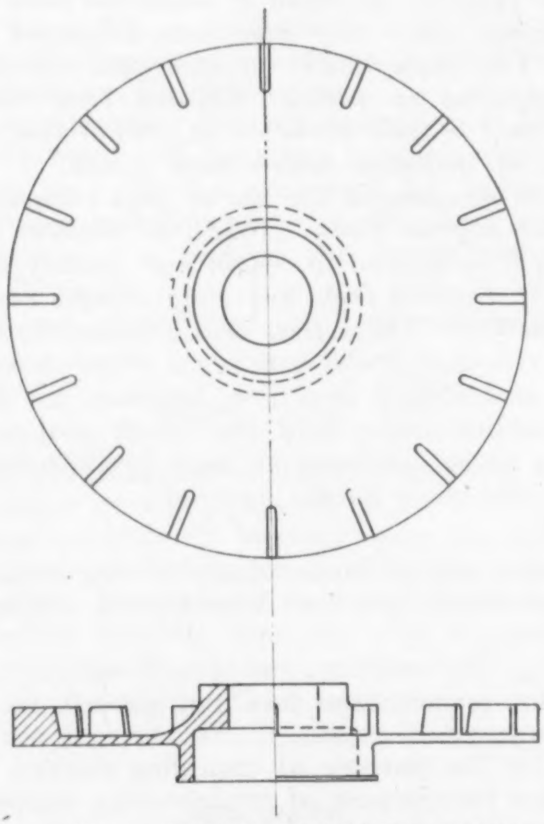


Fig. 1—Sketch Of Malleable Iron Blower Fan Casting Which Was Found To Be So Hard And Brittle That A Small Deformation And Light Hammering Caused It To Break Into Fragments.

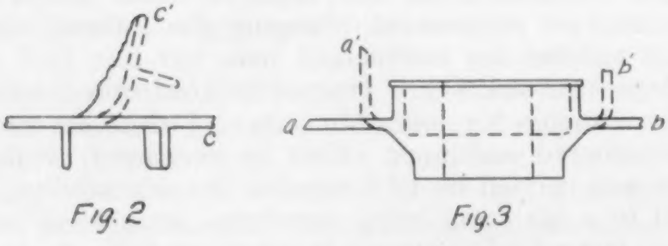


Fig. 2—Sketch of Rim Part Of Casting Which After Annealing Was Bent Through An Angle of 75 Degrees Before Breaking. The Fractured Section Showed A Good Black-Heart Structure. Fig. 3—Sketch Of Hub Section Of Casting Which After Annealing As Described In Text (a) and (b) Bent Through An Angle Of 90 Degrees Without Breaking Or Showing Any Sign Of A Crack Or Rupture.

approximately 75 degrees before breaking and the fractured section showed a good "black-heart" malleable structure. On the hub section of the casting,

Fig. 3, parts (a) and (b) were bent through an angle of approximately 90 degrees without breaking or showing any sign of a crack or rupture. This test demonstrated the fact that hard and mottled iron can be reclaimed by a single heating process.

A second problem of reclaiming motor bearing housings and commutator end plates brought out some new ideas relative to annealing temperatures.

The annealing or malleablizing temperature range of malleable iron is usually given as 700 to 750 degrees Cent. for air-furnace iron and 800 to 900 degrees Cent. for cupola iron. Our experiments however, indicated that this temperature was much too low for consistent results on air-furnace iron. To assure attainment of correct annealing temperatures of a charge

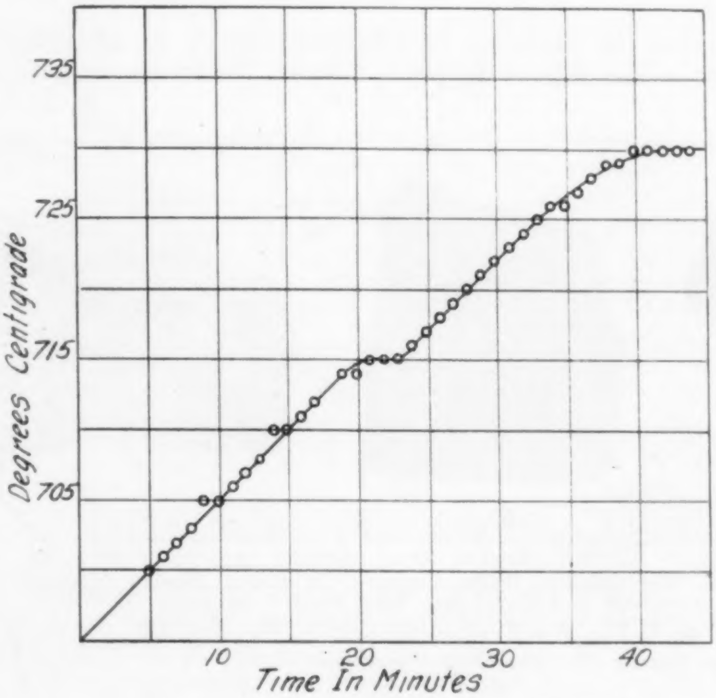


Fig. 4—Heating Curve Taken During Experimental Treatments In Reclaiming Motor Bearing Housings.

of motor bearing housings, the fire end of a thermocouple was placed in a hole, drilled in the side of the casting.

The heating curve of Fig. 4, was taken and the temperature for the starting point of the annealing cycle raised to 730 degrees Cent. or slightly above the critical point 715 degrees Cent. of the casting under observation. This is illustrated by the bends of the curve.

The fracture tests of this casting are shown in Figs. 5 and 6; the original white fracture in Fig. 5, and the malleablized "black-heart" structure in Fig. 6.

On the other hand a commutator end plate constituting a part of the same charge broke sharply with the full white fracture, shown in Fig. 7, indicating that the critical temperature of this iron had not been reached during the annealing operation. The heating curve of Fig. 8 subsequently obtained, proved the correctness of this assumption.

The end plate was then annealed above its critical temperature as shown in Fig. 9, resulting in an excellent malleable structure of Fig. 10. Photomicro-

graphs, Figs. 11 and 12, further illustrate this change of microstructure accomplished by a relatively high annealing temperature. Photomicrograph, Fig. 11, taken before the second annealing shows a perfectly white structure consisting of cementite plus cementite eutectic while photomicrograph, Fig. 12, taken after last annealing, shows a thoroughly malleablized structure of a "black-heart" casting, consisting of a ferrite plus free graphite.

The analyses of the two irons are as follows:

	Combined Carbon Per cent	Graphitic Carbon Per cent	Mang. Per cent	Phos. Per cent	Sulphur Per cent	Silicon Per cent
Motor Housing	0.01	2.00	0.28	0.16	0.068	0.75
End Plate	0.05	1.97	0.24	0.20	0.13	0.83

The difference in analysis is relatively small in all constituents except sulphur and to a less degree in phosphorus. Since air-furnace iron was used

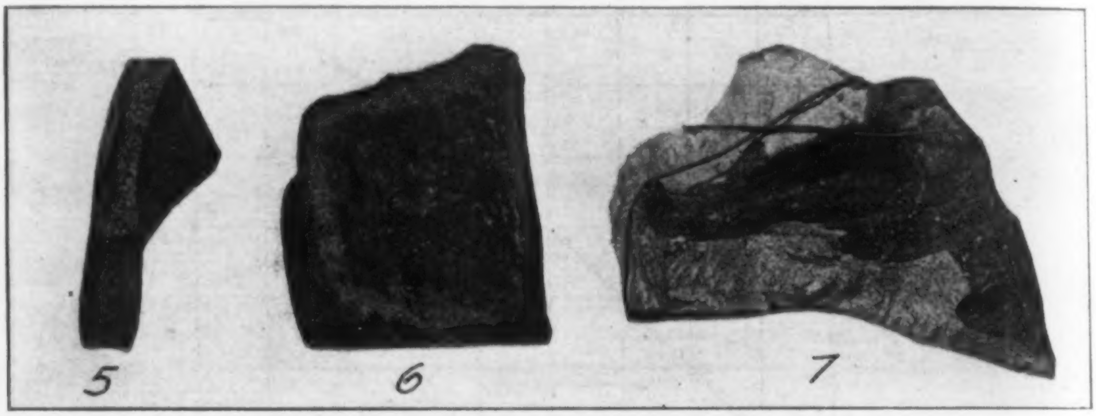


Fig. 5—Shows The Original White Fracture Of Motor Bearing Housings And Commutator End Plates. Fig. 6—Shows A Malleablized "Black-Heart" Structure Of One Of These Parts. Fig. 7—Shows A White Fracture On One Of The Commutator End Plates Which Was Treated In The Same Charge As The Others. This Indicates That The Critical Temperature Of This Iron Had Not Been Reached During The Annealing Operation.

for both castings, it seems reasonable to conclude that the presence of higher sulphur and phosphorus requires a higher annealing temperature than when these limits are relatively low.

A third problem of straightening blower fan castings in a press while heated to a red heat led to a further investigation to determine the temperature to which a malleable iron casting of thin section (⅜-inch maximum) may be heated and held for a reasonable length of time before the graphitic carbon is redissolved or changed back to the cementite (Fe_3C) or combined form, producing a brittle white casting.

A number of malleable iron castings of thin section which were straightened by being heated to a cherry red or perhaps hotter and pressed in a die were returned after this operation in a brittle white condition. They had been soft and malleable previous to the heating. The casting which had been broken was selected for test and was a fairly good malleablized material. It exhibited a "black-heart" malleable grain structure. The casting was heated fairly rapidly in a gas-fired furnace to 730 degrees Cent. and held at this temperature for one-half hour. It was then placed on a cold steel slab and cooled to a black heat of somewhere near 375 degrees Cent. in air, and finally quenched in cold water. The cold casting was then

broken under a hammer at section (a) Fig. 13. The casting bent through an 80 degree angle before breaking and the fracture was sooty, as that of the original casting.

The remaining part of the casting was replaced in the furnace and heated to 815 degrees Cent. and held at this temperature for one-half hour, when it was withdrawn and cooled as above. The casting was broken at (b) Fig. 13 after having been bent through an angle of almost 80 degrees with a fracture of even better grain structure than either the original casting or the

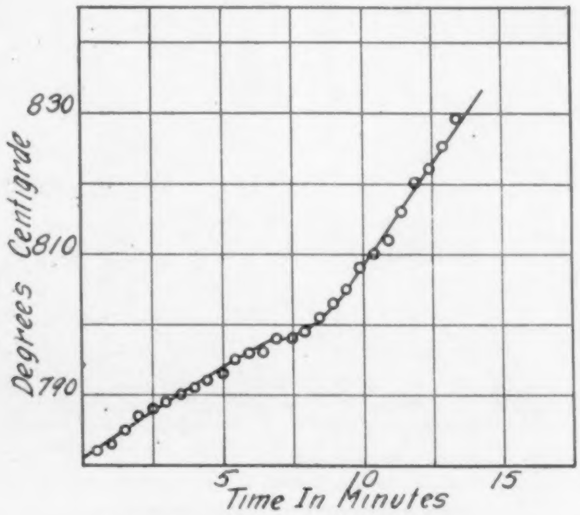


Fig. 8—Heating Curve Taken During Experimental Treatments In Reclaiming Commutator End Plates.

one broken after the 730 degrees Cent. treatment. The remainder of the casting was again put into the furnace and heated to 925 degrees Cent. and held again for one-half hour, and cooled again as above.

After this treatment the fracture as shown at (c) Fig. 13 was sharp and white indicating very brittle iron.

Table I
Effect of Temperature in Malleablizing Iron

	Degrees Centigrade					
	Heated to	Held in furnace	Cooled on cold steel slab	Quenched in cold water	Angle of bend	Grain structure of fracture
Original	...	.....	...	..	70	Black heart malleable
Section A......	730	½ hr.	375	20	80	Black heart malleable
Section B......	815	½ hr.	375	20	80	Black heart malleable
Section C......	925	½ hr.	375	20	Sharp break	White

Examination revealed the fact that the carbon had been redissolved and combined with the iron to form Fe_3C (Cementite).

Results are presented in tabulated form in Table I.

Summary

These tests indicate a wide variation in critical temperatures of different samples of malleable iron, from 715 to 800 degrees Cent. as shown on Fig. 4, even though the range of chemical composition is such as is often found in malleable iron. It also indicates a decided influence of sulphur and phosphorus upon the position of the transformation points.

The employment therefore, of high temperature annealing from 900 to 925 degrees Cent. for malleablizing, is advocated when it is desired to obtain

high quality material with a high degree of ductility from annealing charges representing different chemical analyses.

It may also be inferred that the well known practice of employing higher annealing temperatures for cupola than for air-furnace malleable iron

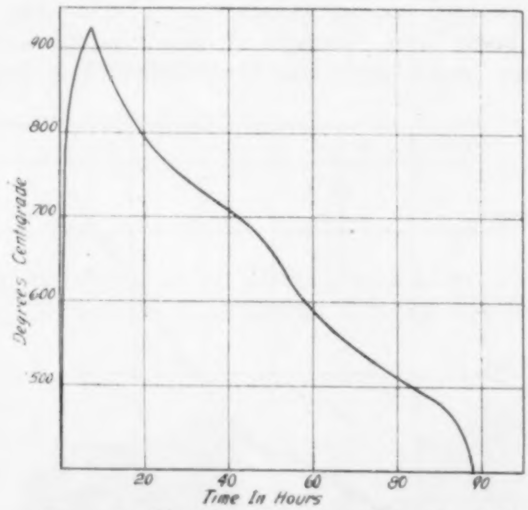


Fig. 9—Electric Furnace Record Taken During The Malleablizing Treatment Of Commutator End Plates, Resulting In Excellent Malleablized Structures.

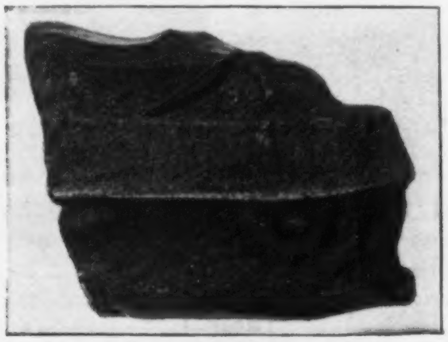


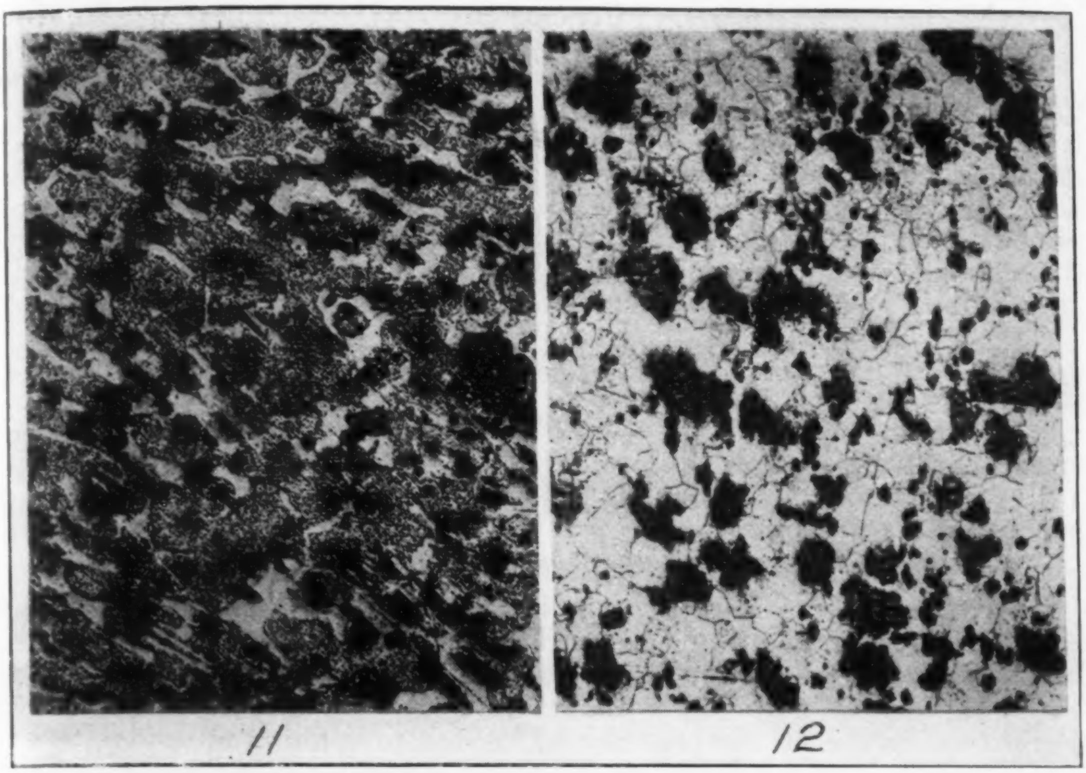
Fig. 10—Fractured Malleablized Casting Showing An Excellent Malleable Structure Resulting From The Annealing Treatment As Shown In Fig. 9.

is due primarily to the higher sulphur and phosphorus content in the charge, rather than purely to the different methods of manufacture. The difference of chemical composition in sulphur and phosphorus does not seem to affect the quality of the product, provided proper temperatures are employed in annealing.

These tests, also demonstrated the fact that it is possible to reheat malleable iron to a proper temperature for straightening without destroying its malleablized structure, but that too high a temperature (925 degrees Cent.) will re-establish the white, hard and brittle structure.

It is therefore safe to conclude that:

1. The straightening of malleable iron castings may be safely done without causing the whitening or embrittling of the casting by heating them to a dark cherry red and then subjecting them to the straightening operation in a forge press, provided the time of holding the casting in the furnace is relatively



Figs. 11 and 12—Photomicrographs Which Illustrate The Change Of Microscopic Structure Accomplished By A Relatively High Annealing Temperature. Fig. 11—Taken Before The Second Annealing Shows A Perfectly White Fracture Structure. Fig. 12—Taken After The Last Annealing Shows A Thoroughly Malleablized Structure Of A Black-Heart Casting. x 100. Specimen In Fig. 11 Was Heated To 730 Degrees Cent. (1346 Degrees Fahr.) Specimen In Fig. 12 Was Heated To 925 Degrees Cent. (1700 Degrees Fahr.)

short and does not constitute a soaking operation of several hours.

2. The method or time of cooling does not seem to lessen the ductility of the castings so long as the carbon component is in the amorphous

Fig. 13—Sketch Of Blower Fan Casting Showing The Type Of Eracture Which Resulted From The Several Treatments Given This Casting As Described In Text.

or graphitic condition. On the contrary, an accelerated cooling is conducive to finer grained ferrite and therefore a tougher and more ductile material.

The reaction of cementation on heating to a high temperature (925 degrees Cent.) is reversible. Therefore, an exceedingly slow cooling after combining the carbon, results in breaking up the cementite into iron (ferrite) and graphitic carbon.

Conclusions

Hard castings are objectionable for two reasons, they are brittle and they destroy tools when machining. In order to eliminate the occasional hard casting from a shipment of malleable iron, it is advocated that a higher annealing temperature above the critical range of all castings, be used in order to malleablize such castings as happen to be high in phosphorus and sulphur. Warped castings may be straightened at temperatures below the critical range without damage. White castings may be properly malleablized in an ordinary open fired gas annealing furnace by correct processes.

Discussion of Paper

Chairman French: Mr. Lynch's very important paper is now before you for discussion.

Mr. Norris: I would like to ask Mr. Lynch if he tried restoring the castings by heating to a lower temperature than the critical point without packing the outside, and if so, what results he had.

Mr. Lynch: Yes, we tried to bring them up to a point below the critical range but found no change in structure up to the critical range. In other words, we heated them up to a point below the critical range for straightening purposes without changing the structure and above the critical range in the presence of oxides to refine and soften.

Mr. Merten: I might add to Mr. Lynch's remarks that we were interested in keeping down the oxidation as much as possible because we didn't want any undue reduction in section, however, we were interested in having the benefit of the decarburized, tough skin in a malleable iron casting since this increases the ductility.

Mr. Loudenbeck: I would like to ask Mr. Lynch what effect the preheating has on the carbon.

Mr. Lynch: Mr. Chairman, we didn't make an analysis of the combined carbon except as was suggested from the fractures. There was no change made that we could observe up to the critical point. When it went above that point we did get a change, making the casting brittle. If they were heated up in the presence of iron oxide we were able to remalleablize the castings.

Mr. Merten: Mr. Loudenbeck, you refer to the reduction of total carbon. Photomicrographs are given in the paper itself and they do show the eutectic ferrite-cementite condition in the light casting, with the sooty, annealed condition in the other. Mr. Lynch has the photographs in the paper. I suppose there is a reduction in carbon, due to the decarburization of the surface, it is hardly possible to heat the casting as high as we did and not decarburize it.

Mr. Loudenbeck: My experience has been that a slight change occurs in preheating. There was practically no combined carbon in the annealed condition.

Mr. Lynch: We found no deleterious results from that.

Mr. Merten: The paper gives results of such tests and it shows that the ductility of the casting actually increased on heating. We had a better fracture after the heating up to about 700 or 800 degrees Cent. and cooled and the bending tests showed up very much better.

FORGING PRACTICE FOR AUTOMOBILE PARTS

By R. T. Herdegen

Abstract

The author of this paper has presented a general and practical discussion of the many items which are involved in the production of drop forgings for automobiles. He discusses the various types of machines which are used in the production of drop forgings both in the eastern and western shops.

The main items or factors which go to make up the total cost of manufacturing drop forgings is reviewed in a general way.

The design of the die and the type of machine used bear a very important relationship to the ultimate cost and it requires close study and co-operation both on the part of the producer and consumer to obtain the minimum cost per unit. Close metallurgical control of the raw material is imperative to uniform quality production.

THE title of this paper should perhaps be "How Automobile Parts Have Developed the Forging Business" rather than "Forging Practice for Automobile Parts," for the reason that the drop forge business was a tender infant until the advent of the automobile. Previous to that time, drop forge work was largely restricted to the making of various tools such as wrenches, pliers, screw drivers and to the fabrication of carriage hardware. The shops making these parts were practically all located in New England and the combined output of the forging shops west of Pittsburgh was probably not equal to the output of one of the larger eastern shops.

Types of Machines Available

There are various machines available for the purpose of making drop forgings. Each machine has its own special good points and its own inherent disadvantages. It cannot be said that there is one particular type of machine which is most suitable for all types of forging work. The type of machine used for making the great bulk of forgings is the drop-hammer. The two main classes of this unit are the steam-hammer and the board-hammer. There has been a great deal of controversy as to the relative merits of these two types of machines ever since the great expansion in the drop forge business started.

Board-Hammers Used Largely in Eastern Plants

Eastern shops were largely board-hammer shops with here and there a stray steam-hammer. With the coming of the automobile, the manufacture of which is practically entirely in the west, there came the development of the huge western shops with which we are all familiar. These shops were equipped practically entirely with steam-hammers.

The result of this development was that eastern drop forge men considered board-hammers the proper type of equipment for forging

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A paper presented before the Detroit chapter of the society. The author, R. T. Herdegen, is vice president and general manager of the Dominion Forge & Stamping Co., Walkerville, Ont.

while the western drop forge men considered steam-hammers the proper equipment. This heated argument continued for several years with the usual result that neither side convinced the other side. Then came the World War with its upheaval in labor conditions, which meant high-priced coal with resultant greater operating expenses for steam-hammers. The gap between the original costs of the two classes of hammers also widened tremendously, which meant greater relative depreciation, interest charges and up keep. At this time in the argument everybody began to seriously consider both types of equipment and began to realize that it was not a case of one type of equipment versus another but a case of getting the proper machine for each specific job.

Headers and Bull-Dozers Used

There are several other types of equipment used in making forgings in addition to hammers, the most important of which is the upsetting machine or so called, header. There is still another type of machine which in its general action resembles the upsetter, namely, the bull-dozer in the restricted sense of that term.

In addition to these units, there are various minor units such as Bradley hammers, special types of air hammers and rolls. These latter units are however restricted in their uses and are usually required in conjunction with the main units of forging practice to perform auxiliary operations. Hydraulic presses are also used for very heavy work of a special character, which would otherwise be made under large open frame hammers, rather than by double frame forging hammers. The main units that will be considered in this paper will be board-hammers, steam-hammers and upsetters.

Determining Costs

Selection of Proper Machine for Efficient Forging

In the early days of the drop forge business the question of the proper machine for a given job was decided solely on the basis of costs. The machine which would do the cheapest job was considered the proper machine for that job. Unfortunately this is still true of a good many shops today.

Three Principal Items Involved in Figuring Costs

Material Costs

In considering the problem from this angle there are three items to consider; the material used, the labor required, and the overhead involved. In general, upsetters use less material in making a job than any other type of forging apparatus. Most typical upsetting jobs are of such a character that there is no loss due to the flash. In other words, trimming is not necessary, the forging comes completed from the unit ready to machine. There is, however, a certain item of lost steel to be considered, namely, the short end of every bar used in upsetting work. The operator starts making forgings from a long bar but soon arrives at a point where the bar is so short that it cannot be used to make forgings. In many cases this short end can be used to good advantage on another job of the same analysis steel or sometimes it even pays to make up a hammer-die to use up these short ends for the

same job as is being made in the upsetter. A short end, however, must always be taken into consideration and sometimes on jobs using a large diameter bar such as a six-inch bar, the expense of putting this large diameter short end to an economic use, will eat up the material saving effected on the first pieces made from the bar.

Labor Costs

In general, the labor costs of making a forging should be more or less the same whether it is made in one type of apparatus or another. In speaking of labor, productive labor only is considered and in the case of the average forging the productive labor is rarely more than 15 per cent of the total cost. Of course, if one type of apparatus will make a great many more forgings in a day than another type of apparatus the labor cost on the first unit will be considerably less per piece; inasmuch as the total daily earnings of an operator should be about the same regardless of which unit is used. Occasionally more men are required to handle the job when made in one type of apparatus than in another, which of course will also increase the labor cost per forging in the case of the former. However, increased production per hour may result which may more than overcome the labor increase.

Overhead Costs

The overhead charge is by far the most important factor in drop forge costs. For most forgings the overhead cost is as much as the material and productive labor cost added together unless the material used is high-priced steel. In the case of the average carbon steel forging, the material and labor charges combined are always less than the overhead charge. In considering the matter of overhead, we should compute this only on the machine-hour basis. In other words, for every piece of apparatus or production center the cost per hour of operation should be determined. This may run all the way from a few dollars an hour to a charge of fifty dollars an hour or even higher. The overhead cost is then manifestly equal to the overhead charge per hour for the production center divided by the piece production per hour. For example, we might consider a unit which costs twenty dollars an hour to run, making ten axles per hour. Estimating on this forging, the overhead cost per axle would be two dollars. The overhead cost then per forging is entirely determined by the production per hour possible on the unit. This does not necessarily mean that it is always best to put a forging on the machine that will produce the greatest number of pieces per hour, because th oveerhead charge per hour on this unit may be so great that the charge per forging is greater than that obtained from a smaller unit making a smaller number of forgings per hour and which, nevertheless, produces a lower cost per forging.

This discussion relative to the merits of the different types of apparatus has been based entirely upon the question of costs of production. The last few years, however, there has been a great advancement in the investigation of the effects of working steel on the ultimate forging purchased. In this connection the question of grain size and arrangement has developed to be of considerable importance, particularly

in the case of gears. It is possible to obtain a grain arrangement in the finished forgings on an upsetter which is usually impossible in a hammer. This is particularly true in the case of gears with a large diameter. In the case of gears with a small diameter, the desired grain arrangement can be obtained by cutting the steel into the proper sized small cylinders and then forging them on end. This process however, is liable to be more expensive than the upsetting process.

It has also been discovered that it is possible to obtain a forging too quickly. The effect of several smashing blows on a piece of steel is such that the ultimate product will not always be as satisfactory as when it is made with a larger number of less vigorous blows. This may mean, however, that fewer forgings per hour can be produced by the latter method which in turn means a higher cost per forging.

The cry of the purchasing agent for the last two years has been entirely on the question of price. Fortunately, however, in a few instances lately the result of the investigations of some of the members of this society has indicated that on certain forgings it was very desirable to obtain a certain grain arrangement or to take more blows or more upset operations on a certain forging. The writer is not a metallurgist but appreciates the fact that the number of blows or upsets required to make a given piece will in many cases materially affect the ultimate wearing qualities of the finished forging. The time does not appear to be very far distant when the purchasing agent in asking for quotations on a certain special forging, will state definitely the number of blows or operations which the purchaser desires to be used in the manufacture of that forging. It is absolutely necessary, however, to convert the purchasing agent to the idea that there is something to forgings besides the price per piece. As long as forging purchasing is done entirely on this basis the man who makes the greatest number of pieces in the shortest possible time will get the order, even though his product is not as desirable as the product which is more painstakingly made but which costs more money.

Die Design An Important Factor

Intimately connected with the question of the number of operations in making a forging, is the question of die design. In the discussion on the number of blows required to make a forging it was assumed that the die was exactly the same whether two or four blows were used on the hammer. It was merely a case of using a lighter hammer with the same type of die. In the forging of many pieces, however, it is possible to regulate the speed at which the metal is obliged to flow by varying the design of the die. The number of operations made on an upsetter is determined practically entirely by the die design which determines the amount of stock to be gathered in any one operation.

The average forging is made in two impressions, the rough and the finished and usually with a break down placed on the side of the die as a preliminary operation. If it is desirable to work the steel slowly, more impressions must be used, but there is a limit to the number of impressions that can be put into one die-block. This means that it is often necessary to have two sets of dies running in two separate hammers. The first set of dies is usually referred to as blocking dies and the second set as the finishing dies. There will prob-

ably be at least two impressions in each of the dies besides the break down in the blocking dies which would mean five steps in the making of the forging.

The Determination of the Proper Number of Impressions is Imperative

Most of the motor car companies have had considerable trouble with connecting rods and it is probable that a great deal of trouble has been due to trying to make a perfect rod with too few impressions. The competition in connecting rods has been probably the keenest competition in the drop forge business. It has been a case of an effort on the part of the manufacturer to make the maximum number of rods per day with the use of the smallest number of pieces of equipment. It is no incentive to a drop forge concern to block connecting rods in one hammer and finish them in another unless the company receives more money for this extra work. A certain well known motor car company recently ordered a quantity of rods specifying that they were to be first blocked and then finished and the die design was to be approved by their metallurgical department. This is certainly a step in the correct direction.

The writer does not wish to indicate from these remarks that it is desirable for every forging to be made as slowly as possible with as many operations as possible. It certainly is true, however, that in the case of a critical part on a motor car where breakage might cause serious damage or perhaps loss of life, that motor car companies should take advantage of the investigations of the "metallurgical department" and purchase forgings not alone on price. They should also consider the manner in which this forging is to be made.

Quality of Steel Used is Paramount

When a drop forge company receives a shipment of steel it should assure itself that the analysis of that steel is correct. If it is not correct it should never work that material into finished product. In addition to the question of analysis there is the very important question of seams. It sometimes happens that surface seams will disappear in the flash in making the forging but this is rare and should not be considered as an excuse to use seamy stock. The forge companies are much better off to refuse absolutely to use seamy stock, certainly in the case of stock which is to be used in connection with upsetters. Stock, which may show only slight surface seams, when worked in an upsetter will open up on flanges in a most surprising fashion and make a forging which is so defective that the average forger will never consider even shipping it from his plant.

This brings up again the old question of forging-quality bars. On the one hand there is the steel company advising the forge man to buy nothing but forging-quality steel, while on the other hand, there is the customer buying the forging as cheaply as possible. A drop forge concern may bid on a certain forging with every intention of using forging-quality bars which means paying the extra charge by the steel company. Before the negotiations are completed he is advised by the purchasing agent that his price is high. He immediately decides to use ordinary forge bars and thus make it possible to quote a lower price.

It is probably true that for many forgings which are not put to any severe strain or which are not particularly difficult to forge, that ordinary bars will be satisfactory, but in the case of certain critical forgings or forgings which require an unusual amount of working, it is desirable to purchase forging-quality steel. As mentioned above upsetting will bring out any defects in a steel bar so that it is usually suicidal to purchase ordinary steel for upset operations.

Steel Frequently Furnished by Customer

A large number of motor car companies make it a practice to purchase the steel for the drop forge man. This is certainly an advantage from two points of view. It enables the motor car company to be sure that the proper steel is used in making their forgings and also ensures uniformity of the product as far as steel is concerned. The drop forge man is also benefited by this procedure because he knows that his competitor will naturally plan on using the same character steel which is sold to all bidders for the same price. If there is any difficulty with the steel the entire problem can be referred to the motor car company which in many instances is able to accomplish more with the steel company than the average forge concern. Also the larger motor car companies are able to maintain an adequate metallurgical department which can investigate the steel problem much more thoroughly than such a department operated by a drop forge concern. The bulk of the drop forge companies are not in a position to be able to maintain the extensive metallurgical departments required to properly check steel purchases; so that it would appear in the final analysis that the method of having the motor car company purchase and be responsible for the steel, is the best method of handling the steel question.

Conclusion

Summing up these brief remarks with reference to forging practices for automobile parts, it would appear that the forging business owes its present great development entirely to the motor car industry and that the direction in which forging practices in the future tend will depend almost entirely upon the interest that this group takes in the forging business. If the American Society for Steel Treating members can convince their respective companies that it does make a difference as to the character of the steel used for forgings and as to the method in which these forgings are made, then the drop forge business in the future will improve and the class of work turned out will be superior to a great deal of that made today. If on the other hand, the motor car companies are interested only in the price of forgings they will merely get a forging which has the correct dimensions but whose internal structure may be very far from that which is desirable for the work to which that forging will be subjected. As a drop forge man the writer hopes that the former alternative will prevail and that the question of quality in drop forgings will receive greater attention in the future than it has in the past.

Discussion of Mr. Herdegen's Paper

Chairman J. L. McCloud expressed the chapter's appreciation to Mr. Herdegen for his interesting presentation and announced that the

speaker would be very glad to answer questions and discuss points in reference to the drop forging of automobile parts.

Mr. Danse: I would like to ask Mr. Herdegen, in regard to the forging of axle sections, whether he considers it better to fuller it and edge it before finish forging, or whether he considers it better to fuller it and edge it and be sure the fullering and edging brings the section down so that it will just fill the impression in the die before finishing.

Mr. Herdegen: I would say that there have been a good many experiments conducted in the forging of axles by different companies, and as the axles are not all the same, what may be very good practice for forging one axle may be very bad for forging another. In general, I would say that it is better to make the steel flow in such a manner that you do not have a cross grain, and it would depend upon the design of axle and size of stock as to which method you would use.

Mr. Danse: You would say, then, that if the axle had very deep flanges on the I-beams it would be better to have two impressions, and if the flanges are not so deep it would be just as good to block it out.

Mr. Herdegen: That would be my idea, yes.

Mr. McCloud: As Mr. Herdegen said, as large a part of the problem as anything is in die design.

Mr. Herdegen: I might make the remark that the drop forge business in the last few years is practically entirely a question of price. That is, you can make any forging you want, to any dimension you want, providing you receive sufficient money to justify that work. During the war we made forgings and they were forged in such a manner that they would not have to be machined. We got them to .001 inch. That meant cold restriking and a lot of other operations. They cost about 25 or 30 cents per pound. They were very expensive, but the people who purchased them felt that they saved enough money in their machining to justify that price. The same thing applies to forgings coming up every day. You do not like a forging if it looks this way or that way, but the forge men can do most anything that you gentlemen want them to do. It is up to you gentlemen to convince your purchasing department that it is worth the extra money that it costs to get the forging the way you want it.

Mr. Blasko: Have you had any experience in forging or rather rolling gears to a size so close that they will go in the car without machining?

Mr. Herdegen: No, I have never had any personal experience with those. I have seen them being made, however. A concern in Cleveland, rolled about 500,000 the same as used for Ford cars. So far as I know they are all running.

Mr. Blasko: Do you know how the price compares?

Mr. Herdegen: Yes, these gears sold a good deal cheaper, but it was hardly a fair comparison, because they were made out of carbon steel, whereas Mr. Ford makes his out of alloy. While the difference of average comparison is not as great as you would figure it might be, still I think it worked out about 15 cents on that gear.

Mr. Blasko: Did they also make some worms?

Mr. Herdegen: Yes, they also rolled some worms. I didn't go into that. The machines are very expensive and the dies are very ex-

pensive, and they don't last long. After you run about three or four hundred you have to take the dies out and regrind them.

Mr. Blasko: Do they roll it in one heat?

Mr. Herdegen: Yes, it is a quick job, but hard on your machinery.

Mr. McCloud: We had some experience out in Dearborn with some forged gears,—differential gears and differential pinions, that were pretty well forged to size. However, they were not sufficiently close to size but what they had to be machined, the teeth generated, beside other machining operations, and after running them for a little while in the machine shop and all the way through the plant we found that the actual cost was as great if not a little bit more in the case of the gears that were forged; that is, the extra cost of the forging was a little bit more than the cost of cutting the teeth. In other words, it didn't cost us any more to take a roughing cut on the gears than it did to forge them. Possibly that was mostly owing to the life of the dies. The cost of forging the teeth in, was of course, dependent on the life of the dies, and to get sufficiently close to maintain the limits for roughing, the dies cost too much.

We have been quite successful in the use of a worm which was partially rolled to size. Of course, more material was taken off so that there was a distinct saving in the case of the worm, but not in the case of the gears.

Question: What makes up the overhead cost and what is the largest item in this cost?

Mr. Herdegen: What part of the machine are you interested in?

Question: On an axle for instance, a $50.00 an hour machine.

Mr. Herdegen: Yes, that would be a large machine. The biggest item would be on the upkeep of the machine itself.

Mr. Herdegen: Well, we have a machine that gives an answer of $39.00. That is the largest one we have, so I will give you its analysis. In figuring overhead the only units in your shop that could earn you any overhead are your actual production units. In other words, the boiler room, electrical department and other non-productive departments are all charged up against the hammer shop so it must stand the whole burden. In figuring this charge we take the hours that each unit operates and multiply those hours by the rate in each case. If your shop is running 70 per cent you will earn all your overhead very nicely, but unfortunately the last two years they have not been running 70 per cent.

Referring to the total charge of $39.00 per hour which is the machine rate on an eight thousand steam hammer, it may interest you to know that the same is divided up about as follows:

All handling charges of material covering unloading, shearing, trucking and grinding as well as inspection in the shop and shipping room, produce a total of $4.50. The total coal charge including the boiler room labor and overhead amounts to $4.00. Furnace oil, the cost of producing furnace air and the repairs on the furnaces increase the overhead $7.00 per hour. Maintenance of machinery and equipment including the repair parts purchased and the labor involved in their machining and installation total $6.000. Shop charges for superintendence, insurance, taxes and depreciation are $5.00 more. Administration, commercial expense and sales expense total $4.50. The complete cost of dies which

covers material, labor and overhead involved in their production mean a charge of $8.00. The sum total as you will note, is $39.00.

Question: Isn't it general practice to have the customer stand the die charge

Mr. Herdegen: Yes, but the average forge company doesn't get enough out of dies to buy stamps. The charge made by the average company never pay for making these dies.

Mr. Learmouth: Mr. Herdegen, along that same line I have some figures here. We check our cost per thousand pounds of forgings produced. With our way of estimating our die and tool cost, that is; everything connected with the cost, amounts to $3.84 per thousand pounds of forgings produced and the die upkeep runs about $3.24. In other words it costs as much to repair the dies as they originally cost. Then our hammer repair, which is the labor and repair parts for the upkeep of the hammers runs about $2.50 per thousand pounds. Our furnace, which includes brick, labor, fireclay and oil, runs about $1.80 per thousand pounds of forgings produced.

Mr. Herdegen: What is your total per thousand pounds of forgings produced?

Mr. Learmouth: $11.38. Of course, that is just for those four items. We have other accounts but I cannot recall just what they are.

Mr. Herdegen: Of course, that would really vary depending on the size units used?

Mr. Learmouth: Well, that is taking an average. Of course, if we were a contract shop we perhaps would not estimate that way.

Mr. Herdegen: Of course, being your own consumer you don't have to worry about that.

Mr. Learmouth: That is just the point, we do. When our purchasing department comes along and says "We can buy that forging cheaper than you can make it," that puts us in hot water.

Mr. Atkinson: Is that cost $39.00 per ton?

Mr. Herdegen: No that is the cost per hour of running that particular machine. If that machine turns out only 39 forgings in that hour there is $1.00 overhead on each forging. On a certain hammer you may at one time have only one man working, and another time you may have half a dozen or more. The cost of operating the hammer is the same regardless of whether you have one, two, three or four or more men running it. That is why the forge men do so much to try to make the die produce the maximum number of forgings per hour.

Mr. Atkinson: I think that these points Mr. Herdegen brings out in connection with the cost of operations in the forge shop are some that everyone of us should keep in mind in connection with the operation of our heat treating departments. We hope a little bit later in the season to have a meeting in which heat treating costs will be discussed. The points brought up in regard to die costs may give us some idea of the line along which we should work in computing costs in our heat treating departments.

Mr. Blasko: In that case you mentioned, would that hammer produce a ton of forgings?

Mr. Herdegen: That would depend entirely on the particular design of forging put in that hammer you see. That hammer is going to use a certain amount of steam regardless of whether you turn out

one ton or two tons. It may be a forging that is complicated to make, and it may only turn out as few as ten an hour, and then it may be a simple one and you may get forty an hour. You can imagine making a large flat gear, you would turn out a large number, and the next time put in a complicated truck axle, and you turn out less.

Mr. Blasko: Do you charge in accordance with that?

Mr. Herdegen: Yes, sir.

Mr. Blasko: Some of them are quite high.

Mr. Herdegen: Yes, they are. Did any of you gentlemen see those complicated forgings at the American Society of Steel Treaters exhibition. Did you notice that gun carriage forging. I think it cost around $250. It was very complicated, had to be made in a very large hammer, and they only produced about thirty or forty a day.

Mr. Blasko: How large was it?

Mr. Herdegen: The net weight I think would be around 250 pounds. It cost over 10 cents per pound.

Mr. McCloud: It is just a question of analysis of cost. That is why this talk Mr. Atkinson referred to is going to be so interesting. I think too few of us in the heat treating work realize the necessity of cost analysis, and most of us are ignorant of the methods of attack.

Question: I would like to ask whether the steel companies have any right to expect the forging company to stand any loss?

Mr. Herdegen: I would like to know why, when we pay that extremely high price so as not to have any liability, why we should assume it. I would carefully lay all the defective pieces out and ask them to come over and see them.

Mr. Learmouth: I check on that because it seems to be the custom of the steel companies to try to educate the forging companies. We have a small amount of loss, 2 per cent loss and if that, while it is small, were added to a, say, 3 per cent loss in steel, it would be more than I believe we should stand. We have to stand our amount of loss in the forge shop, and I think it no more than right that they stand their own.

Mr. White: For material made in the same size ingot do you notice any difference between the electric furnace and the open hearth?

Mr. Herdegen: That I would have to refer to the metallurgical department, Mr. White, as I do not know.

POURING TEMPERATURES OF STEEL CASTINGS

By H. K. Briggs

Abstract

This paper, dealing with pouring temperatures of steel castings, indicates that the foundryman seldom pays much attention to the pouring temperature of the steel he is turning into his molds.

The author of this paper has demonstrated the effect of varying pouring temperatures on the physical characteristics and properties of castings poured into similar molds under uniform conditions using the same heat of steel for these tests, keeping all factors excepting the temperature of the molten steel constant.

The rate of cooling the steel from the molten to the solid state has considerable effect upon the resulting microstructure of the casting. With a Widmanstatten structure caused by slow cooling from an elevated temperature, weak castings result, which can only be improved by a suitable heat treatment. Photomicrographs and physical test results accompany this paper.

Introduction

IN ALL of the work on the heat treatment and working of steel, but little mention is made of the effect of the temperature at which the original ingot or casting was poured into the mold. If variations in the pouring temperature affect the structure and properties of the product in such a way as to render it an inferior article capable of being improved to the desired quality, then it is a very proper consideration for a body of men engaged in the treatment of steel.

The aim of this paper is to show the effect of varying the temperatures at which steel castings of the same composition are poured. Five castings of the same heat were poured into molds of the same dimensions all air dried for three days, made from the same sand at the same time, thus eliminating all variables as far as possible. The castings were poured at temperatures varying from that at which the steel would just run, to that at which it smoked excessively and cut the sand to a marked extent. They were cooled over night in the mold. The usual physical tests and photomicrographs are herein presented to show the varying effects of this treatment.

Pouring of Castings

The castings were cast in blocks 4 x 8 inches in section with three lugs running the length of the bottom side, 7/8-inch round by 11 inches long. A 4-inch riser gave a total head of 12 inches. These lugs were nicked and knocked from the block, and turned to A. S. T. M. standard 2-inch gage length, threaded end test bars.

Chemical Analysis

The following is the chemical analysis of the heat:

	Per Cent
Carbon	0.27
Manganese	0.48
Silicon	0.23
Phosphorus	0.033
Sulphur	0.048

A paper by H. Kenneth Briggs, metallurgist with the Minneapolis Electric Steel Castings Co., Minneapolis, Minn.

Pouring Temperatures

The blocks were poured at the following temperatures:

Series	Temperatures by Pyrometers Degrees Cent.	Degrees Fahr.	Observations
1	1470	2678	Solidification set in across top of ladle
2	1485	2699	Slight solification as in No. 1
3	1500	2732	Metal smoking very slightly
4	1525	2771	Metal smoking excessively
5	1650	2822	Metal smoking more than in No. 4 and in turbulent condition

Physical Properties

With the exception of block 5, two tensile test specimens were machined from each block and were pulled on a tensile testing machine. Block 5 was filled with large blowholes, showing that the excessive heat used in casting had been such as to render the steel wild and the blocks unsuitable for test. Table I shows the physical properties of the bars tested.

Table I
Tensile Test Results

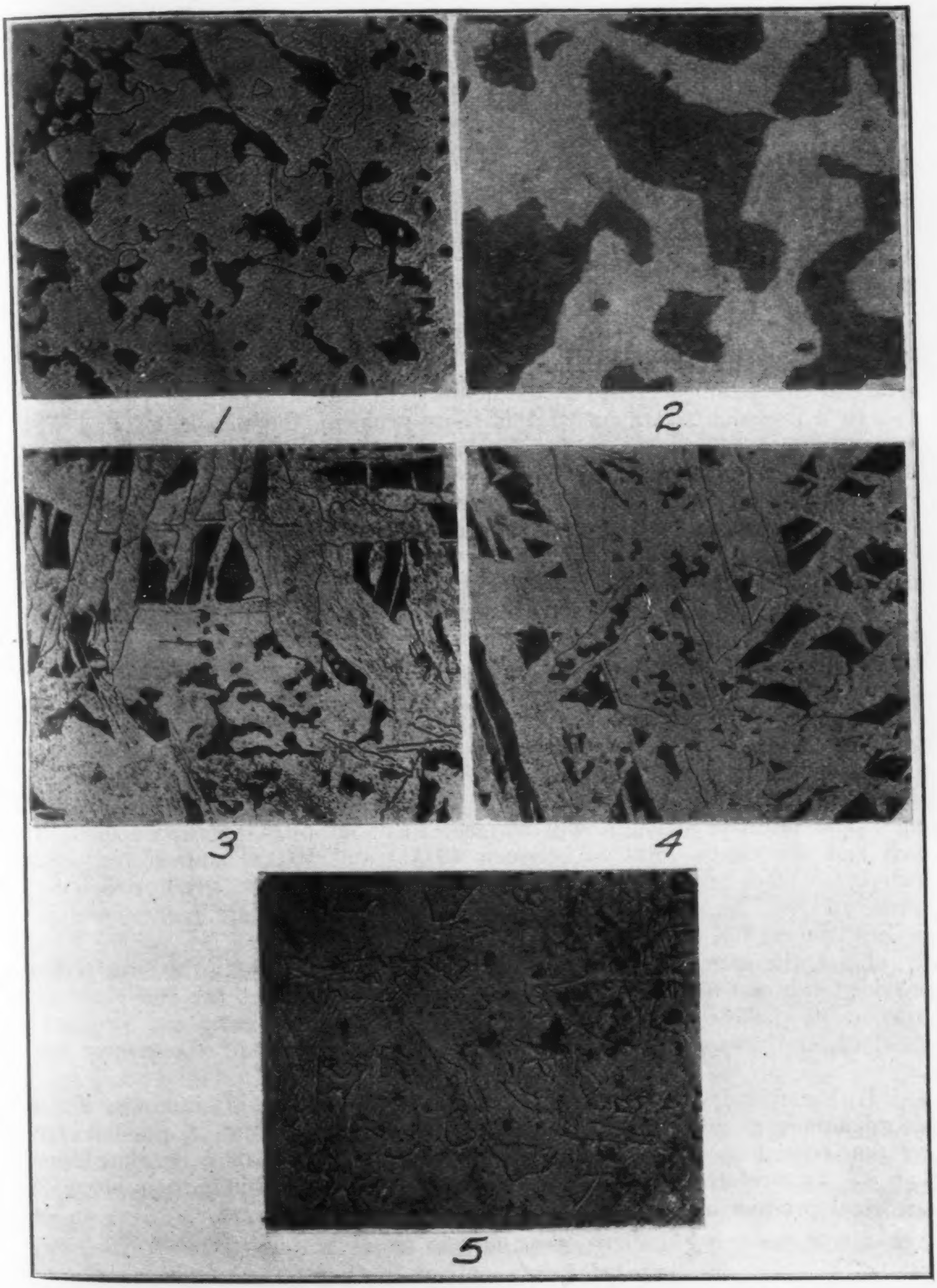
Bar No.	Elastic Limit Lbs. per sq. in.	Ultimate Strength Lbs. per sq. in.	Reduction Area Per Cent	Elongation Per Cent	Elastic Limit / Ultimate Strength Per Cent
1A	25,250	55,150	40.3	29.0	46.1
1B	25,500	55,450	39.7	32.0	46.1
Average	25,375	55,300	40.0	30.5	46.1
2A	21,125	55,600	32.4	26.5	37.9
2B	23,875	55,575	33.1	27.5	42.6
Average	22,500	55,587	32.7	27.0	40.2
3A	25,000	56,175	26.8	20.5	44.5
3B	20,100	56,650	32.8	24.5	36.5
Average	22,550	56,412	29.8	22.5	40.5
4A	21,350	41,875	15.2	5.0	51.2
4B	20,750	52,650	9.2	7.0	39.5
Average	21,050	47,272	12.2	6.0	45.3
5A 5B	Blocks were defective, thus preventing the machining of test bars.				
Grand Average	22,869	53,643	28.7	21.5	43.0

As will be observed in reviewing the above table, the elastic limit averaged 22,869 pounds per square inch, varying from a minimum of 21,050 to a maximum of 25,375 pounds per square inch. The ultimate strength averaged 53,643 pounds per square inch, varying from a minimum of 47,272 to a maximum of 56,412 pounds per square inch. The reduction of area varied consistently from 12.2 per cent to 40.0 per cent with an average of 28.7 per cent. The percentage of elongation varied from 6.0 per cent to 30.5 per cent with an average of 21.5 per cent. The ratio of the elastic limit to ultimate strength showed an average of 43.0 per cent with a variation from 40.2 to 46.1 per cent.

It is readily seen that for all practical purposes there is no variation in the elastic limit, ultimate strength and hence none in the relative ratios, all variation caused by pouring temperatures exhibiting itself in reduction of area and elongation variations. The latter quite consistently follows an even descending curve when plotted against increasing temperatures.

Photomicrography

Fig. 1 and 2 shows the structure of series I. It will be observed in Fig. 1 that the structure is large grained and irregular with many dark island areas which at 400 diameters magnification are seen to be composed of sorbite embedded in a ferrite matrix. The sorbitic structure is typical of the dark



PHOTOMICROGRAPHS OF CAST STEEL

Fig. 1—Photomicrographs of test specimen of series 1 cast at 2678 degrees Fahr. × 100. Fig.2—Photomicrograph same as Fig. 1 × 400. It will be observed that the structure is large grained and irregular. The dark island areas are sorbite embedded in a ferrite matrix. This sorbitic structure is typical of the dark areas of the remaining Figs. Figs. 3, 4 and 5 show a very marked Widmanstatten structure and have been photographed at 100 diameters magnification. Fig. 3 represents series 2 cast at 2699 degrees Fahr. Fig. 4 represents series 3 cast at 2732 degrees Fahr. Fig. 5 represents series 4 cast at 2771 degrees Fahr.

areas of the remaining series, hence these series are shown in Figs. 3, 4 and 5 at 100 diameters magnification. It will be observed that in Figs. 3, 4 and 5 a very marked Widmanstatten structure exists, which is considered by several leading metallographists to be the typical structure of cast steel. Fig. 5 shows a specimen from series 4 and it will be seen that it is filled with many minute blowholes which were invisible to the naked eye. This condition is the logical fore-runner of the large blowholes which were noted in series 5.

Conclusions

In conclusion, it seems that, provided the mold is cooled sufficiently slowly from the molten state of the metal, a Widmanstatten structure will result. This structure is not of the strongest, is rather brittle, and therefore, should be avoided. The physical results prove this, as both the reduction of area and elongation decrease as the quantity of this structure increases.

In a previous treatment of this same problem, the tensile tests of which proved valueless because of the inaccuracy of an only available tensile machine, the author performed a similar experiment as here, except that the blocks were stripped as soon as they became solid enough, and were cooled in air. A Widmanstatten structure here exhibited itself, but the planes of symmetry were not as well marked as in the present case, the straight lines and lanes being curved due to the more rapid cooling.

By annealing this latter set of similar specimens at just above their critical point for 20 minutes, this objectionable structure was broken down completely, the result being a well defined pearlite. On a drawback to 400 degrees Cent., typical troostite developed.

Although the physical results of this latter set were so very inaccurate as to render them valueless, the author's experience has shown that the Widmanstatten structure can be effectively broken down by a simple anneal just above the Ac_3 point for sufficient time, depending on the section of the casting. The ultimate strength will increase to about 80,000 pounds per square inch and the elastic limit to between 40,000 and 50,000 pounds per square inch for a steel of the analysis under consideration. The grain size will be small, and will be composed principally of sorbite and ferrite, with the possibility of pearlite.

Thus, the annealing of such castings is the problem of the heat treater, provided the castings are not poured so hot as to render the steel wild and full of blowholes. No holes being present, the heat treater can produce a standard, uniform product, irrespective of the structure of the poured casting.

To the foundryman who, as a rule, does not anneal his castings, it is to his advantage to pour his castings at as low a temperature as possible, having due regard to the proper running of his steel. It may be stated here, that we, as steel treaters, realize the advantage of annealing to improve the cast steel product as a regular part of the foundry routine.

MIGRATION OF CARBON FROM STEEL TO INGOT IRON[1]

By O. Z. Klopsch and H. F. Roberts

Abstract

This paper points out the possibilities of obtaining quantitative results of the rate of migration of carbon from steel to ingot iron, and its depth of penetration. That such migration will take place has been known for some time, but the difficulties encountered in obtaining quantitative results, has probably hindered similar investigations.

It was necessary that the authors discontinue their work at a time when the solution to the major part of their difficulties seemed likely and it is hoped that the suggestions offered here will aid those desiring to carry on investigations of similar nature. The results obtained by the present authors, while still being incomplete, show definitely that there is a transfer of the carbon from the steel to the carbonless ingot iron. Photomicrographs and curves illustrate the work so far accomplished.

IN THE November, 1920, issue of the *Journal of Industrial and Engineering Chemistry,* E. G. Mahin and E. H. Hartwig of the department of chemistry, Purdue University, published a paper entitled "Inclusions and Ferrite Crystallization in Steel." In this paper they proved quite conclusively that under certain conditions of contact and temperature carbon can be made to migrate from a carbon steel to ingot iron.

Based upon this premise the authors of the present paper proceeded to determine the rate of migration and the depth of penetration of carbon which takes place between eutectoid carbon steel and ingot iron when heated at various temperatures and for various periods of time.

Procedure

In planning this work it was realized that it was necessary to have extremely close contact between the ingot iron and the steel and in order to accomplish this a hollow cylinder of ingot iron was carefully drilled, and a plug of 0.835 per cent carbon steel 0.003 inch larger in diameter than the opening in the cylinder was carefully prepared. The ingot iron cylinder was then expanded by heating to a temperature of 600 degrees Cent. (1112 degrees Fahr.) and the cold plug was quickly driven in.

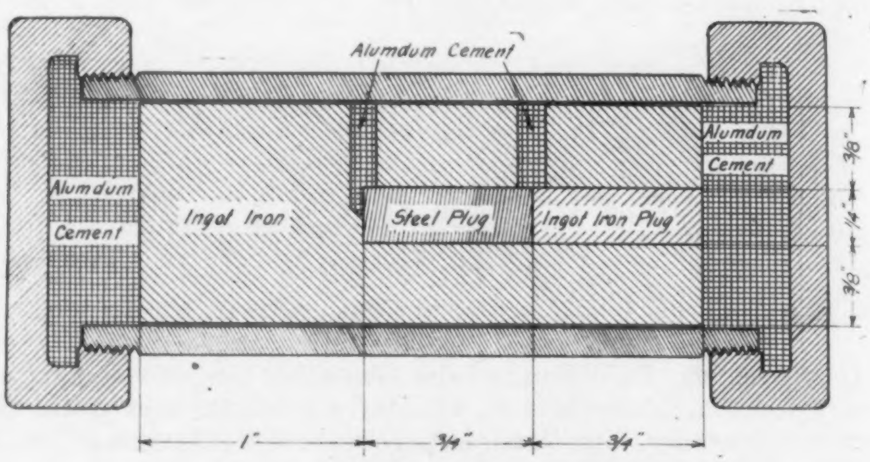
It was found that while the ingot iron filled in the machining and drilling imperfections fairly well, some scale formed on the cylinder due to oxidation on heating for expanding, which probably played some part in removing carbon from the eutectoid plug. Probably a better way to obtain good contact and exclude oxidation would have been to have the hole in the cylinder slightly tapered, with a corresponding taper on the plug, so that a driving fit could be obtained, resulting in a more intimate contact between the cylinder and the plug.

In order to prevent the escape of carbonaceous gases a cylinder was drilled part way through longitudinally and the steel plug was inserted and a plug of ingot iron used to seal the drill hole. Small vent holes were drilled to allow an

1. Submitted as a part of a thesis for the degree of Bachelor of Science in Metallurgical Engineering, Case School of Applied Science, Cleveland, O., 1922.

escape for the air behind the plugs; these holes being closed with alundum cement. Fig. 1 shows a sketch of this arrangement and the manner in which it was enclosed in a short length of standard 1-inch pipe, which was provided with caps at each end; thus this container assisted in limiting the amount of air coming in contact with the test specimen and so helped prevent the escape of carbonaceous gases from the specimen of steel.

By excluding oxygen, it was hoped that the migration of carbon would take place from solid to solid without the use of a gas as a medium, but the evident presence of oxygen due to scale and oxide inclusions in the ingot iron,



Air Behind the Plugs

Fig. 1—Sketch Showing Arrangement of the Steel and Ingot Iron Plugs Inserted in the Ingot Iron Cylinder. Small Vent Holes Were Drilled to Allow an Escape for the Air Behind the Plugs

makes it impossible to say how the carbon did actually migrate. The partial decarburization of the plug and the apparent failure to find sufficient carburization of the cylinder to account for this, indicates that some carbon may have been lost by combination with the oxides.

Where close contact was obtained the carburization of the cylinder seemed to approximate the decarburization of the plug, while in samples where this condition was not obtained, either no carburization of the cylinder or very little took place, although the plug had been quite materially decarburized.

Methods of Heating Specimens

In the operation of shrinking the steel plug into the ingot iron cylinder, a gas-fired, muffle type furnace was used. Temperature measurements were made with a pyrometer.

The heating of specimens at the migration temperatures was carried on in electric furnaces of the resistance type. Three different combinations were used in this heating, the choice being governed by the time that the specimens were at temperature. The first combination was a verticle muffle resistance furnace manually regulated with a rheostat, using base metal thermocouples and a potentiometer. The second combination was a muffle type furnace using the hairpin type of resistance heating units. A low-resistance voltmeter was used in conjunction with a base-metal thermocouple for obtaining temperature measurements. This furnace was used in runs requiring a temperature of 900 degrees Cent. (1652 degrees Fahr.) or more. The third combination, used for long runs, was a verticle muffle resistance furnace automatically controlled with an automatic temperature recorder attached.

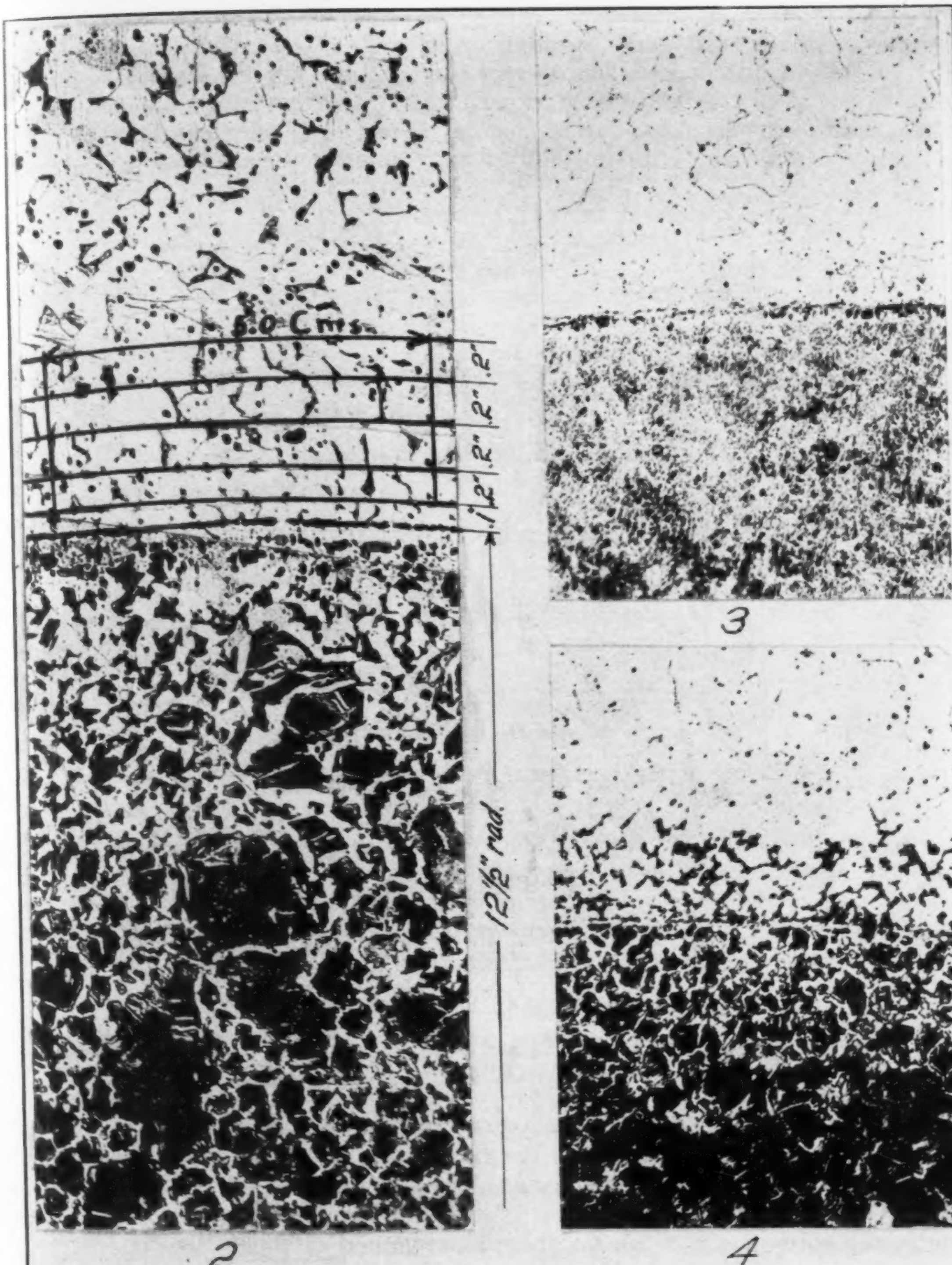


Fig. 2—Photomicrograph illustrating the method of determining the pearlite content of the ingot iron after heating; Fig. 3—Photomicrograph of Specimen X which was heated for 48 hours at 650 degrees Cent. (1202 degrees Fahr.); Fig. 4—Photomicrograph of Specimen A heated for eight hours at 800 degrees Cent. (1472 degrees Fahr.). All magnifications × 100.

Temperature Used

The temperatures used to obtain migration were above the Ac_3-$_2$-$_1$ range of the eutectoid plug and above the Ac_2 point of the ingot iron surrounding

the plug. These ranges were determined on a standard transformation point recorder, with the following results.

Ingot iron $Ac_2 = 765$ degrees Cent., (1409 degrees Fahr.)

$Ac_3 = 908$ degrees Cent., (1666 degrees Fahr.)

Eutectoid steel $Ac_{3\text{-}2\text{-}1} = 765$ degrees Cent., (1409 degrees Fahr.)

After determining experimentally that no migration took place in 48 hours

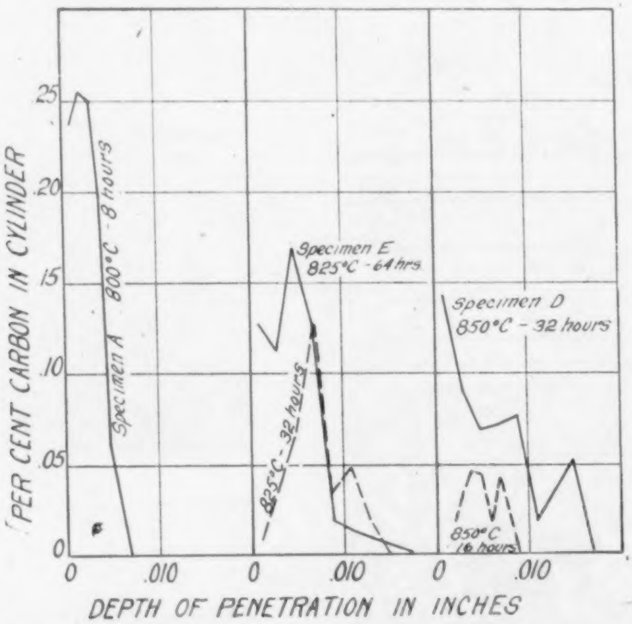


Fig. 5—Carbon Penetration Curves for Specimens A, D and E Heated at 800, 850 and 825 Degrees Cent., Respectively

at a temperature of 650 degrees Cent. (1202 degrees Fahr.) temperatures above the critical ranges were then used.

In order to determine quantitatively the amount of carbon which had migrated, the samples were cut transversely, polished, etched and photographed at at 100 diameters magnification.

Determining Amount of Penetration of Carbon

The photomicrographs were examined by a comparator which is comprised of two microscopes sliding on a bar over a finely divided scale. By this means measurements were made of the linear dimensions of the pearlite areas where they were cut by arcs of concentric circles drawn using as a center of radius the center of the plug. Since the photographs were taken at 100 diameters and the core is 0.125 inch in radius, the imaginary center of the core will be 12.5 inches from the concave side of the edge of the core shown on the prints. This method is shown in Fig. 2.

The amount of carbon which had migrated into the cylinder was determined at 0.1 to 0.5-inch intervals on the print (actually .001 to .005 inch on the specimen) on arcs swung from the established center. The determination was made by taking the sum of the linear dimensions of the pearlite areas where they had been cut by the arcs and multiplying by the factor of carbon in pearlite (.0085) to get the amount of carbon. The sum of the linear dimensions of the pearlite grains multiplied by .0085 and divided by the length of the arc considered, gave of course, the fractional carbon content of the field at the zone cut by the arc. Having determined the amount of carbon in each zone it

was then possible to plot the percentage of carbon against the depth of penetration, with temperature and time, a constant. Carbon penetration curves for specimens A, B, C, D, and E are shown in Figs. 5, 6 and 7.

From the amount of pearlite found, the carbon at each interval of space from the junction could be readily calculated. These amounts when plotted

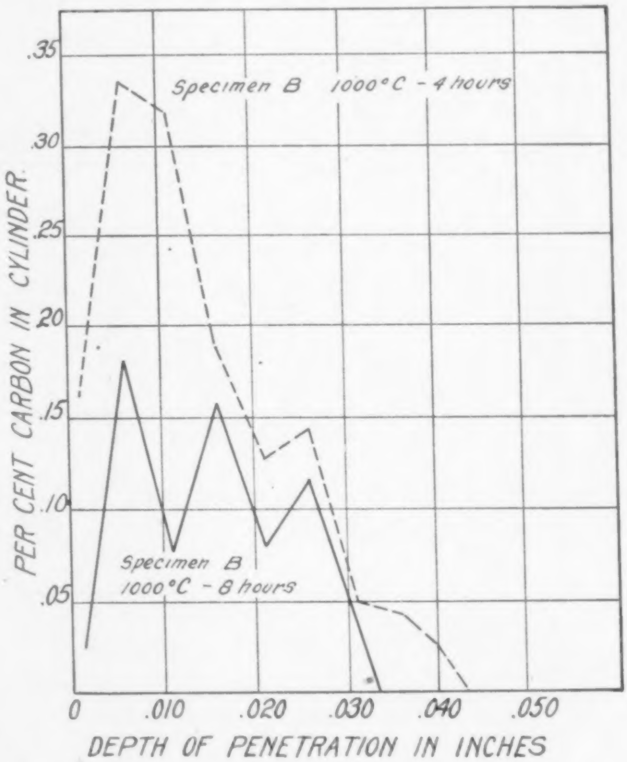


Fig. 6—Carbon Penetration Curves for Specimen B Heated at 1000 Degrees Cent. for Eight Hours

showed a surprising regularity, indicating that a very close determination could be made, with sufficient time and care.

Specimen X shown in Fig. 3 shows that no migration was obtained at a temperature of 650 degrees Cent. (1202 degrees Fahr.) for 48 hours. It will be noted from the photomicrograph that the mechanical bond was very good and therefore it was concluded that no migration across the boundary took place at this temperature with the time interval used. There is a considerable increase of free ferrite in the peripheral part of the eutectoid plug, which is difficult to explain.

Specimen A shown in Fig. 4 heated at a temperature of 800 degrees Cent. (1472 degrees Fahr.) for a period of 8 hours gave a uniform curve of the type found generally throughout this problem. This was the lowest temperature above the Ac_{3-2-1} range of the steel plug at which it was attempted to obtain migration. The bond here is excellent and the pearlite has migrated uniformly into the ingot iron.

Specimens E_1 and E_2, Figs. 8 and 9, were heated at a temperature of 825 degrees Cent. (1517 degrees Fahr.) for 32 and 64 hours respectively. While thy show a greater decarburization of the plug and a greater depth of penetration of pearlite into the cylinder, they have a less complete bond between the plug and the cylinder than specimen A and the amount of migrated pearlite is not so great.

A temperature of 850 degrees Cent. (1562 degrees Fahr.) was used in heating specimens D_1 and D_2. Specimen D_1 was heated for 16 hours and specimen D_2 for 32 hours. These are shown in Figs. 10 and 11 respectively and show an inferior mechanical bond. Here it will be noted that the penetration curves for specimens E_1 and D_2 are very similar, as might be expected with a diffrence of temperature of only 25 degrees Cent. but on examination

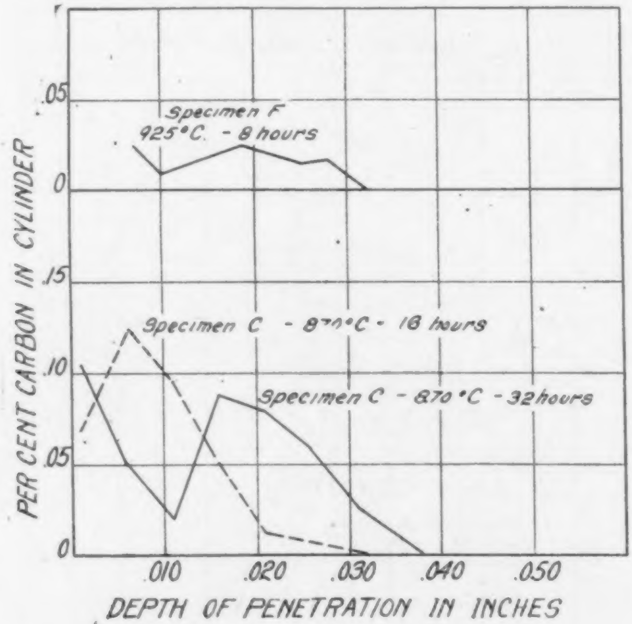


Fig. 7—Carbon Penetration Curves for Specimens C and F Heated at 870 and 925 Degrees Cent., Respectively

of the photomicrographs, D_2 plug is seen to be more decarburized. Specimen D_1 does not compare favorably with either specimen A, which was heated 50 degrees Cent. lower in temperature and one half as long, or with specimen D_2 which was heated to the same temperature. Its decarburization compares fairly well, but the lack of uniformity in the carburization of the cylinder shows up plainly and shows the effect of poor contact.

Specimens C_1 and C_2, Figs. 13 and 14 were heated to a temperature of 870 degrees Cent. (1598 degrees Fahr.) for 16 and 32 hours respectively. They show a very distinct band of oxide at the bond, which necessarily must mean a poor contact between the plug and the cylinder. Specimen C_1 plug shows the least decarburization of any with the possible exception of specimen A, while the depth of penetration is greater, as might be expected at the increased temperature. The pearlite seems to be better distributed throughout the cylinder, that is, the concentration is less than at corresponding points in specimens D_1 and D_2 so that the curve is considerably flatter.

Specimen F, Fig. 12 gives very poor results as far as the carburization of the cylinder is concerned, but seems to compare with the other specimens as regards the decarburization of the plug. In this specimen as in the others the large number of sonims will be noticed and these may play an important part in the lack of consistency of many of the results. The pearlite appears to have penetrated the deepest into the ingot iron in this specimen although, there is very little of it. This suggests that perhaps at this high temperature when the carbon or carbide came in contact with an inclusion it was oxidized and removed. The deep penetration occurring with such a small concentration

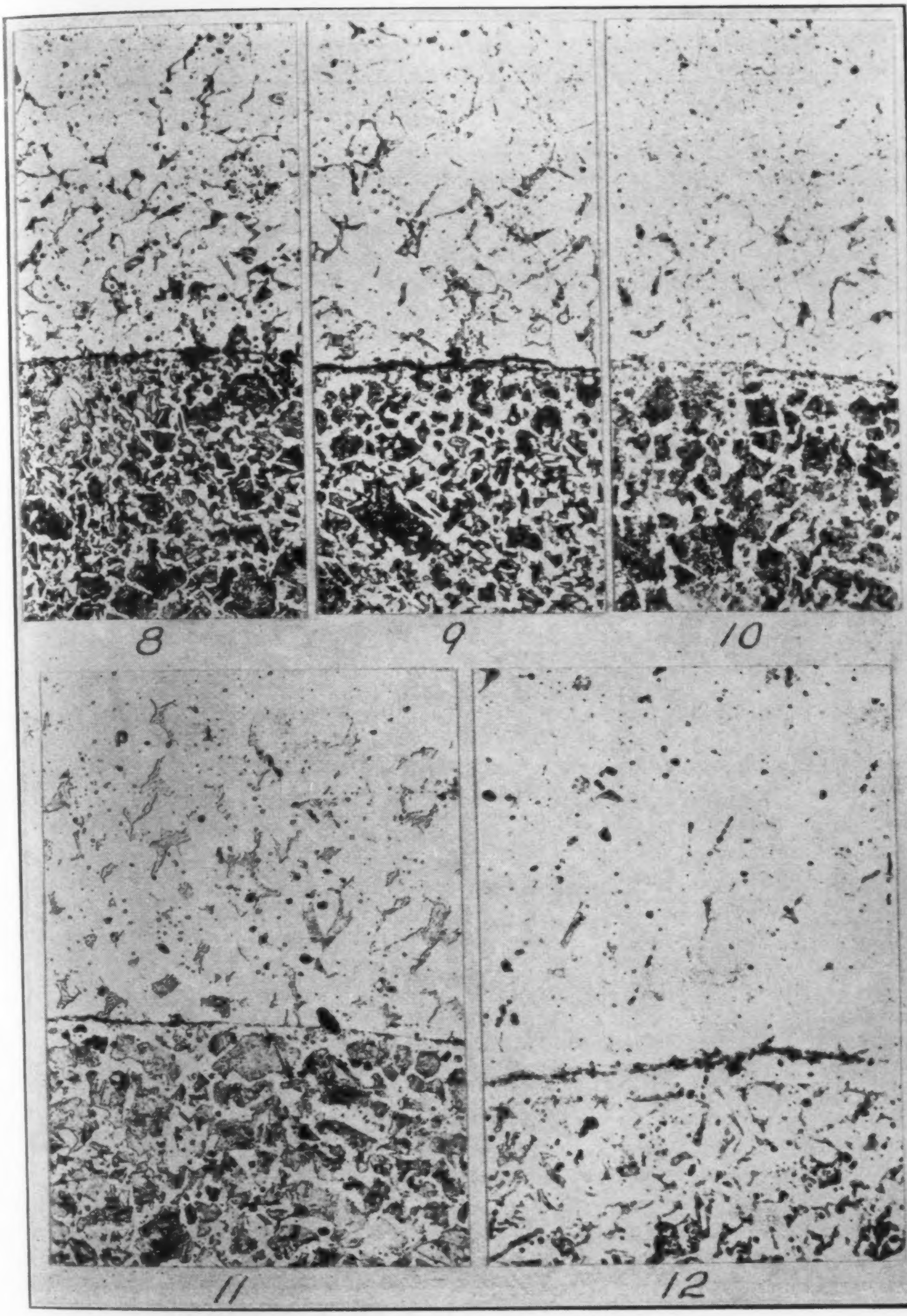


Fig. 8—Photomicrograph of Specimen E_1 heated 825 degrees Cent. (1517 degrees Fahr.) for 32 hours; Fig. 9—Photomicrograph of Specimen E_2 heated to 825 degrees Cent. (1517 degrees Fahr.) for 64 hours; Fig. 10—Photomicrograph of Specimen D_1 heated to 850 degrees Cent. (1562 degrees Fahr.) for 16 hours; Fig. 11—Photomicrogrph of Specimen D_2 heated to 850 degrees Cent. (1562 degrees Fahr.) for 32 hours; Fig. 12—Photomicrograph F heated to 925 degrees Cent. (1697 degrees Fahr.) for eight hours. All magnifications $\times$ 100.

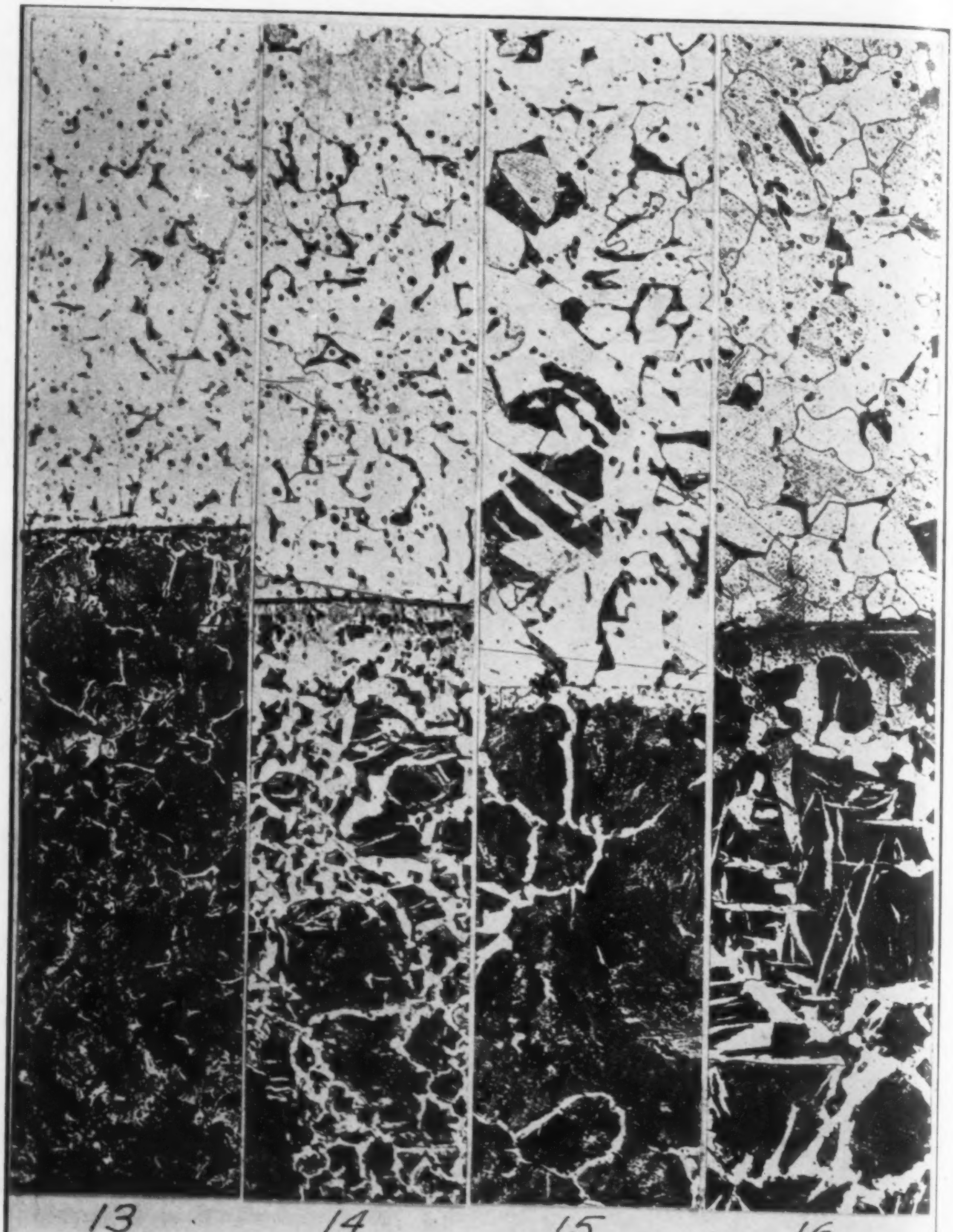


Fig. 13—Photomicrograph of Specimen C_1 heated to 870 degrees Cent. (1598 degrees Fahr.) for 16 hours. Fig. 14—Photomicrograph of Specimen C_2 heated to 870 degrees Cent. (1598 degrees Fahr.) for 32 hours. Fig. 15—Photomicrograph of Specimen B_1 heated to 1000 degrees Cent. (1832 degrees Fahr.) for four hours. Fig. 16—Photomicrograph of B_2 heated to 1000 degrees (1832 degrees Fahr.) for eight hours. Magnifications of all specimens × 100.

seems to indicate that some carbon had escaped contact with any inclusions and therefore had not been removed, and since the time at the temperature had been sufficient the carbon had migrated to this greater depth.

Specimens B_1 and B_2, Figs. 15 and 16, heated at 1000 degrees Cent. (1832 degrees Fahr.) for 4 and 8 hours respectively, show the maximum depth of migration of all the specimens, however, specimen B_2, which was held for 8 hours, shows a lesser peneration than specimen B_1, which was heated 4 hours. One might almost think that the samples had been interchanged, but on examination of the photomicrograph it is easy to see that this is not the case as the grain size of specimen B_2 is much larger than Specimen B_1 and a greater amount of decarburization of the plug has taken place. It will be noticed that specimen B_2 has a black border at the junction while specimen B_1 has a good clean molecular contact. This is probably the explanation for this irregularity.

Discussion and Summary

As evidenced by the results obtained in this investigation uniformly good mechanical bonds between the steel plug and the ingot iron cylinder seem to be essential for consistent results where the difference in time at heat for the specimens of a series is comparatively small. The exclusion of oxygen likewise is imperative.

A migration of carbon takes place between the steel plug and ingot iron cylinder above the A_3-$_2$-$_1$ range of the eutectoid steel plug and above the A_2 range of the ingot iron cylinder. Migration does not take place below the critical ranges at the temperature and time used in these experiments.

Although some of the results obtained are not explainable, however, most of them show a fairly well defined curve for the rate and depth of migration. The best results were obtainable at the higher temperatues, where a greater degree of migration takes place.

In summarizing the results of this investigation we find that they may be stated in the following seven divisions.

1. With close physical contact, oxygen being excluded, fairly accurate quantitative results are obtainable as to the amount of migration and the depth of penetration of carbon into ferrite.
2. A tapered plug driven into a tapered hole with considerable pressure should give better results than a cylindrical plug shrunk into a ring, when such shrinking causes oxidation.
3. Heat-treating the specimens in a vacuum would eliminate the presence of oxygen from without and do away with loss of carbon in that manner.
4. The iron cylinder should be as free from oxide sonims as possible to eliminate any possibility of carbon loss.
5. Migration of carbon takes place from the steel plug to the ingot iron cylinder at temperatures above the Ac_3-$_2$-$_1$ range of the plug in measurable quantities.
6. A plug of hyper-eutectoid steel or silicon-free hard iron might be used in order to eliminate free ferrite, so that the decarburization of the plug can be used as a quantitative means of determining the carbon migration as well as the carburization of the surrounding cylinder.
7. A large number of cross sections should be taken on each specimen and the pearlite intercepted by circles drawn with the center of the plug as a center, should be measured on the entire circle in order to get the best average results. Longitudinal sections would also probably aid in getting better average results.

NOTES FROM THE BUREAU OF STANDARDS

Effect of Ammonia on the Surface of Steels of Increasing Carbon Content

IN co-operation with the Fixed Nitrogen Research Laboratory, the bureau made a microscopic examination of specimens representing a series of steels varying in carbon content from 0.02 to 0.98 per cent exposed to a current of ammonia at temperatures in the range of 100 to 700 degrees Cent. The purpose of this test was to determine the effect of change in carbon content upon the method of attack of heated ammonia. No change was observed on the specimens up to 400 degrees Cent.; at 500 degrees Cent. a film of white nitride was followed by the layer of nitride needles. At 600 degrees Cent. this effect increased, while at 700 degrees Cent. a new compound of nitrogen was formed following directly the film of white nitride layer. At 700 degrees Cent. with two low carbon steels the nitride needles removed further from the edge to the center. They are absent at that temperature in high carbon steels of 0.49 to 0.98 per cent carbon. Twelve micrographs were taken and a detailed report submitted to the Fixed Nitrogen Laboratory.

Investigation of Invar—36 per cent Nickel Steel

A study has been made of the ingot structure of the small ingots cast for this investigation, and the relation of the structure to the forgeability of the alloy. It has been found that although the ingots have been cast in chilled molds, the rate of cooling is not sufficiently rapid to prevent the formation of excessively large columnar crystals producing a very brittle ingot which breaks readily on forging.

As a result of these tests, ingots will be cast in water-cooled molds to increase the rate of cooling and thus prevent, if possible, the formation of the large columnar structure, making the ingots more readily forgeable.

Wear Test of Steel

The investigation of the resistance to wear of steels has been previously mentioned and variations in wear caused by different arrangement of the apparatus has been described.

During the past month a study has been made of the effect of keeping the surfaces of the specimens clean and free from all adhering abraded particles. A cloth buffing wheel, rotated at high speed by an electric motor, has been used successfully for this purpose. It has been found that when the wearing surfaces are thus kept free of abraded metallic dust, the rate of wear drops to an almost negligible quantity compared with the rate when the wearing surfaces are not kept clean by the buffing wheel.

Enameling Properties of Cast Iron

As it has been claimed that gray cast irons, for example, such as are used for bath tub castings, vary widely in their enameling properties, the bureau has been examining specimens of this class of iron to determine wherein the differences lie. Twenty specimens of cast iron were secured from different manufacturers and examined as to microstructure, but no differences which could be considered of importance in affecting their enameling properties have been found. The work, however, will be continued.

Testing of Steel Hoisting Rope

Methods of testing steel hoisting rope and of inspecting such rope in service to determine when it needs replacement are subjects in which mining

and elevator companies are much interested, and the bureau has been asked to undertake an investigation to determine practicable methods for such testing and inspection. A member of the bureau's staff presented a paper on the subject at the meeting of the American Institute of Mining and Metallurgical Engineers on Feb. 21, 1923, and plans for the proposed investigation are under discussion with the bureau of mines and other interests concerned. In anticipation of a small appropriation for carrying on this work during the coming fiscal year, the bureau is making plans to begin intensive work on the problem as soon as possible.

Inview of the nature of the inspection desired, any test which may be developed must be nondestructive. Of all such tests so far considered, magnetic analysis appears to show the greatest promise, and consequently this method will be given first attention. The paper referred to above will be published in the *Transactions* of the American Institute of Mining and Metallurgical Engineers.

Tests of Welded Tanks

The investigation of the strength of about 50 tanks, some of which had been welded by gas and some by electricity, has been completed. This work, which was carried out in co-operation with the American Bureau of Welding, was begun on Dec. 4 and completed on Feb. 9, and gives reliable information on the strength of welded tanks for the consideration of the pressure vessel committee of the boiler code committee of the American Society of Mechanical Engineers.

The results showed that double-V longitudinal welded seams are much stronger and more reliable than single-V welds. Recommendations were also made covering the design and construction of the heads. The pressures at which these tanks failed were so high that confidence in the safety of welded tanks which are properly constructed has been greatly increased. The method of testing, by hammeriing the weld while the tank is under pressure of one and one-half times the working pressure, was discussed. Although this test did not prove as effective in showing up defective welds as had been hoped, its use is, nevertheless, justified.

Another acceptance test proposed in this report is to increase the pressure until the shell of the tanks reaches the yield point. These tests show that the tanks are safe after being tested in this way. As it is probable that tanks having large outlets would be seriously deformed, and therefore, rendered unserviceable, this test is not likely to be adopted, but an increase in the test pressure will probably result.

It is especially commendable to note that the Bureau of Welding, which represents one of the youngest of the engineering industries, has a large number of important problems which it expects to solve. Their importance will be realized when it is considered that they effect almost every one because of the waste of material which results when designs are based on insufficient data or are influenced by prejudice.

Head and Eye Safety Code

The second edition of the National Safety Code for the protection of the heads and eyes of industrial workers has come from the press, and copies can be secured from the superintendent of documents, government printing office, Washington. The first edition of this code was completed in 1920 and has found wide application in the industries which call for protection to the eyes of workmen. Protection of this sort is needed in work such as chipping,

riveting, grinding, stone dressing and other operations where small flying particles are common; in processes where splashing metal, fumes and caustic chemicals are encountered, and in acetylene and electric welding and furnace work where the eye cannot be exposed to sources of intense heat and light.

The revision of the code was carried out by a sectional committee of the American Engineering Standards committee which consisted of 25 representatives of the various interests involved, such as state officials, employers, employes, insurance companies, and manufacturers. The chairman of the committee was Dr. L. R. Thompson, of the United States public health service, and the secretary was Dr. M. G. Lloyd, of the bureau of standards.

Carburization of Steel

An investigation of the effect of the quality of steel upon its carburizing properties and particularly its hardening properties after carburization was suggested to the bureau of standards by commercial metallurgists as a problem of very considerable commercial importance. In order to obtain a wider expression of opinion on this matter, a circular letter was sent to approximately 100 prominent metallurgists. The replies which have been received all indicate the desirability of carrying out such an investigation and the practical importance which the results would have. As soon as the necessary material (abnormal steels) can be obtained, the work will be started.

Gases in Monel Metal

The bureau has just completed determinations of oxygen and hydrogen in samples representing three phases of the deoxidation of monel metal. The samples were all from 50-pound blocks cast during the progress of a regular heat. These samples represent (1) the metal at the time of tapping the furnace before the addition of any deoxidizers; (2) the above metal after the addition of ferromanganese in the ladle, and (3) the above metal after the further addition of magnesium in the ladle, that is, after all additions have been made. Both oxygen and hydrogen in the metal decreased rapidly with the progress of the deoxidation. The finished metal, as represented by the last sample of this heat and by samples of completely deoxidized metal from two other heats, contains from 0.002 to 0.005 per cent oxygen. All samples appear rather porous under a magnification of 100.

A sample of monel metal prepared as above, except that a portion of the deoxidation was carried out in the furnace rather than entirely in the ladle, showed no porosity, and no oxygen could be detected. A sample of monel metal from a Herault furnace heat, which had been completely deoxidized in the furnace, likewise was entirely sound and contained no oxygen. Thus, of the five samples of finished monel metal examined, the three which were deoxidized by addition of ferromanganese and magnesium in the ladle were porous and contained from 0.002 to 0.005 per cent oxygen, while the two which were deoxidized entirely or in part in the furnace were sound and contained no oxygen.

Solders for Aluminum

Circular No. 78 of the bureau of standards entitled, "Solders for Aluminum," has recently been revised. It will soon be available from the superintendent of documents, government printing office, Washington, D. C.

Most of the metals commonly used in solders, except magnesium, are electro-positive to aluminum, so that any metals used in making a soldered

joint of aluminum act electrolytically in the presence of moisture as positive galvanic poles accelerating the corrosion of the aluminum. Magnesium cannot be utilized advantageously even though it is electro-negative to aluminum because the metal disintegrates rapidly in the presence of moisture. Therefore, soldered joints of aluminum which are to be exposed to moisture should be protected against corrosion by paint or varnish. Various compositions of zinc-tin and zinc-tin-aluminum solders give the best results.

The tensile strength of a good aluminum solder is about 7000 pounds per square inch because those with higher tensile strength usually have such a high temperature of complete liquidation that they are unsuited for soldering purposes. As a rule, the strength of an aluminum soldered joint depends upon the type and workmanship.

Tests of Welded Rail Joints

Two welded 7-inch rail joints were recently tested for the Welded Rail Joint committee of the American Electric Railway association and the American Bureau of Welding. One of the joints, a thermit weld, failed at an ultimate load of 600,000 pounds. The other joint, of the welded fish-plate type, failed at about 200,000 pounds. Transverse tests were also made on similar welds. These tests illustrate the methods which will be used in testing several hundred joints representing the types at present in use in this country.

Recent Publications of the Bureau of Standards of Especial Interest to our Readers

S 463 Preparation and properties of pure iron alloys: II. Magnetic properties of iron-carbon alloys as effected by heat treatment and carbon content. W. L. Cheney.

S 464 Preparation and properties of pure iron alloys: III. Effect of manganese on the structure of alloys of the iron-carbon system. Henry S. Rawdon and Frederick Sillers Jr.

The Question Box

A Column Devoted to the Asking, Answering and Discussing of Practical Questions in Heat Treatment—Members Submitting Answers and Discussions Are Requested to Refer to Serial Numbers of Questions.

NEW QUESTIONS

QUESTION NO. 78. *Does microscopic or macroscopic examination of a fatigue failure indicate, even approximately, how long the crack has been forming, or how many times the stress was applied during the growth of the crack?*

QUESTION NO. 79. *Does the apparent grain size of a fatigue fracture vary with the load applied to cause failure, or with the fatigue strength of the material?*

QUESTION NO. 80. *Does a banded fatigue fracture indicate interruptions in the growth of the crack?*

QUESTION NO. 81. *How can you distinguish between a fatigue failure in ductile metal and a sudden failure in a metal which was brittle at the time of the rupture?*

ANSWERS TO OLD QUESTIONS

QUESTION NO. 27. *What is the function of the high phosphorus and the high sulphur content in the so-called automatic screw stock steel?*

ANSWER. By C. T. Patterson, metallurgist with the Solvay Process Co., Syracuse, N. Y.

High phosphorus and high sulphur cause the chip to break up easily so that it will not clog the machine. Phosphorus is dissolved in the metal, not uniformly but concentrated in patches or individual grains, each of such grains being relatively brittle.

High sulphur must always be accompanied by high manganese or the steel cannot be rolled. The manganese and sulphur form nonmetallic globules or drops of manganese sulphide which may be drawn out in rolling. This sulphide is very much weaker than the steel and is quite brittle and whenever it occurs in a chip a break is also almost certain to occur.

QUESTION NO. 59. *Is a sulphur content of 0.067 per cent detrimental to the proper carburizing of a low carbon steel having a low manganese and phosphorus content?*

QUESTION NO. 64. To what extent can the deep etching of specimens of steel be applied to routine examination of incoming material?

ANSWER. By H. G. Keshian, metallurgist with the Waterbury Mfg. Co., Waterbury, Conn.

This method of inspecting steel has its advocates as well as its opponents. Some of the steel companies are not inclined to accept it, but there are others who favor it and are selling their products subject to deep etch test. The method, of course, is comparatively a new one and like every new idea has its handicaps and imperfections and consequently some of the conclusions derived from its application are subject to dispute. But this is to be expected and it is rather desirable that it should be so, for opposition of this nature not only will help to improve the method, but it will also prevent some of us from carrying it to the extreme, a tendency which seems to be closely associated with everything new.

The deep etch, when properly and carefully applied, is of great value in revealing the structural condition of steel. It is a quick method of inspection whereby seams, blow-holes, segregations, pipes, cracks and similar defects can be detected. One great and perhaps main difference between the deep etch test and other methods of inspection is this. In other methods, for instance, the tensile test, hardness tests or chemical analysis, certain limits can be set and these limits can be expressed in numerical values and any material showing values outside of these limits can be rejected. With the etch test, however, definite limits cannot be established. The amount or the extent of various defects when disclosed by the etch test vary greatly and at times some of these defects are so small that it is quite difficult to draw the line of demarcation between a satisfactory and unsatisfactory piece of steel and the question in a case like that simply resolves itself to a mere matter of opinion. Yet this difficulty is not as great a shortcoming to the etch tests as it may appear and any such controversy can easily be settled by good judgment and fair play in the light of mutual benefit.

In the course of time we will know more about the value and the limitations of the method by the aid of our increased knowledge on the life of tools and parts made from steels possessing various structures as revealed by the etch test. In other words, we must judge the value of the etch test like any other test in its relation to the life or the tool or as commonly known, the service test, and in order to improve the method to its highest stage of usefulness the facts obtained by means of the etch test and service test should by all means be correlated.

According to the writer's experience with the method for some years it is safe to say that the method is an exceedingly valuable one as a means of detecting defective steels before they are made up into tools and machine parts. It is also his experience that no matter how satisfactory the material may be from the standpoint of chemical analysis and no matter in what reputable steel mill the material has been manufactured unless such a test is applied to the steel there is a constant danger for some material of defective structure slipping into the tool room and causing waste of time and money. Aside from being able to detect unsound material, the etch test will also enable us to allocate the steel for various jobs. For instance, by means of this test, one can easily pick out a bar of steel with the best structure and chemical composition for the most intricate and expensive tools, and in this way one

eliminates good many blames which usually surrounds every one that has anything to do with a tool, and above all it means starting right from the beginning.

To sum up, the main problem connected with the tool steel with which the tool steel user has to contend with, is whether or not the steel that he is going to make up into tools is structurally sound and of right chemical composition. Deep etch test has been found of great value in the attempt to solve this problem. It should be, therefore, supported by every one concerned with the problem and the method should be developed and standardized as much as possible.

QUESTION NO. 64. *To what extent can the deep etching of specimens of steel be applied to routine examination of incoming material?*

ANSWER. By J. O. Liebig, metallurgist, Lancaster Steel Products Corp., Lancaster, Pa.

The deep etching of specimens on incoming material can be carried out very satisfactorily as routine in selecting 10 per cent of incoming material. I presume that incoming material, in this case, is meant hot-rolled or cold-drawn bars or wire.

A satisfactory etching solution to use is equal amounts of hydrochloric acid and water. The samples can be placed in large evaporating dishes and solution poured over the samples, making it possible for a great number of samples to be etched at one time.

A great many defects are brought out by deep etching, some of the most common being seams, pipes and non-metallic segregations.

In inspecting lots of steel received by etching should 10 per cent of the material be insufficient for proper check, further samples can be taken and a good idea obtained as to the acceptability of the material.

Of course, local conditions in the various plants determine to what extent the material should be sampled. It is more or less a matter of judgment.

QUESTION NO. 67. *What is the reason for the fact that a piece of steel quenched in brine will be harder than the same piece of steel would be if quenched in water, providing that the quenching temperatures and quenching medium temperatures are the same in each case?*

QUESTION NO. 69. *Is sulphur up to* .10 *per cent detrimental to the quality and physical properties of an automotive steel?*

QUESTION NO. 71. *How do the physical properties compare between a* 0.35-0.45 *per cent carbon acid open-hearth steel and an alloy steel of either* 3.5 *per cent nickel or* 1.5 *per cent nickel and* 0.50 *per cent chromium neither heat treated?*

QUESTION NO. 72. What elements are conducive to good electric butt-welding of steels?

QUESTION NO 73. Does electric butt-welding destroy the physical properties developed in a steel which has been heat treated prior to the welding operation?

QUESTION NO. 74. Why shouldn't a bar of steel rolled from a locomotive axle be better than one rolled direct from the billet made from the original ingot?

QUESTION NO. 76. Why are cold drawn carbon and high-speed steels sometimes supplied with a copper coating? Does this coating affect the steel in any way, or is it merely a lubricating agent in the drawing process? Is it necessary or desirable to remove the coating before hardening?

Abstracts of Technical Articles

Brief Reviews of Publications of Interest to Metallurgists and Steel Treaters

SERVICE FOR MEMBERS

The Library Bureau of the American Society for Steel Treating is operated to give to the members quickly, reliably and at the minimum expense the following service:

1. A complete copy of the magazine article referred to in any periodical you may be reading.
2. A translation of foreign articles that would help you with your work.
3. A list of references to books and articles on any metallurgical subject.
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Photo Print Copies of articles, drawings, etc., 25c per 10 x 14-inch sheets.

Searches, abstracts, etc., $2.00 an hour.

Translations, $6.00 per thousand words for French or German; $7.50 and upward for other languages.

Reference card service, giving reference to current magazine articles, $10.00 a year in advance, and 5c for each card mailed.

Members desiring to avail themselves of this service should address Library Bureau, American Society for Steel Treating, 4600 Prospect Ave., Cleveland, Ohio.

USE OF LIQUID FUEL IN METALLURGICAL FURNACES. By R. C. Helm, in *Blast Furnace and Steel Plant*, page 549-546 (1922).

The above article gives the use of fuel oil and tar and also discusses the various types of burners used. It states that the successful use of fuel oil depends on furnace design, as well as proper methods of distribution and on burners which will thoroughly atomize the fuel. For further development mechanical injection of the oil and the use of the recuperative principle for the gas must be perfected. The discussion given deals principally with open-hearth furnaces and furnaces for the heat treatment of wire products.

HARDNESS AND HEAT TREATMENT OF MINING DRILL STEEL SHANKS. By C. Y. Clayton, in *Transactions* of American Institute of Mining and Metallurgical Engineers No. 1203 (1923).

The article states that the hardness of mining drill shanks varies between 196 and

782 Brinell, the greater number of steels showing values between 364 and 444. Methods of heat treating vary not only between different mines but also between operators. Water, oil and air are the quenching media used. The length of shank treated varies between ½ and 8 inches. The results show that if drill shanks are to give satisfactory service a standard method of heat treating must be adopted by each shop.

HEAT TREATMENT OF STEEL CASTINGS. By H. C. Ihsen, metallurgical engineer, Westinghouse Electric & Manufacturing Company, in *Forging and Heat Treating,* March, 1923, page 138-143.

In this articles the author discusses the characteristics of steel castings in the raw state as well as the heat treated condition. The correct treatment of these casings with reference to size and composition is also considered.

A NEW FORM OF TEST BAR FOR THE NOTCHED-BAR SHOCK TEST. By Messrs. Saniter and Baker, in *Revue de Metallurgie,* No. 19, page 633 (1922).

This article says that according to Hadfield, low-carbon steels can be classified as either ductile or brittle, depending on the rate of the shock, while according to Stanton contradictory results can be obtained with the same steel depending on the section of the test-bar. In mild steels the shape of the bar in use at the present time involves considerable deformation and incomplete rupture. In order to overcome these drawbacks, the authors devised a bar notched on three sides, having the same useful cross-section as the usual bar. The same thickness and notch were used as on the standard British Engineering association bar, but the width was increased to allow for the two side notches. Tests were carried out with a Charpy pendulum. The results showed that the deformation of the broken bars was reduced to a minimum, and that the energy absorbed was lower than that in the standard test. In steels with high brittleness, the brittleness found was higher with thick bars than with thin ones, and similarly with low brittleness, consequently this explains why comparable results cannot be obtained with bars of different dimensions.

HOT WORKING OF METALS. By R. Genders, in *Bulletin* of British Non-Ferrous Metals Research Association, No. 7, page 7 (1922).

The author in this article states that hot-working may be defined as a mechanical treatment at a temperature above that at which recrystallization takes place rapidly. The proper working temperatures of a number of brasses are given, and the extrusion process is discussed.

OBSERVATIONS ON THE CONSTRUCTION AND INSTALLATION OF HYDRAULIC FORGING PRESSES. By W. R. Ward, consulting engineer, Lyells, Virginia, in *Forging and Heat Treating,* March, 1923, page 143-146.

In the above article is given a description of the manufacture of forging presses as well as various operations and materials.

CORROSION OF IRON. By J. N. Friend, in Iron and Steel Institute, page 156 (1922).

In this article the author gives a survey of the present knowledge of the corrosion of cast iron and steel. A method is also given whereby the life of the metal may be prolonged.

LINING ACID ELECTRIC FURNACES. By J. M. Quinn, U. S. High-Speed Steel & Tool Corp., in *Iron Age,* April 19, 1923, page 1101.

The author gives the various materials which can be used and the method of handling them. The best lining is also described.

THE METALLURGY OF SEMI-STEEL. By David McLain, in *Forging and Heat Treating,* March, 1923, page 151.

The above is a lecture that was delivered before the British Foundrymen's Convention in Birmingham, England, June, 1922 and deals with historical facts concerning the development of semi-steel.

THE CRYSTALLOGRAPHY OF CEMENTITE. By N. T. Belaiev, in *Revue de Metallurgie,* page 573 (1922).

In this article the subject is discussed in detail and is illustrated with five photomographs.

PREPARATION AND PROPERTIES OF PURE IRON ALLOYS. EFFECTS OF CARBON AND MANGANESE ON THE MECHANICAL PROPERTIES OF PURE IRON. By R. P. Neville and J. R. Cain, in *Scientific* Papers of Bureau of Standard, No. 453.

More than one hundred alloys were prepared from purified iron, carbon and manganese, and the compositions were chosen as to bring out the effects of carbon and manganese on pure iron.

SPECIFICATIONS FOR STEEL CASTINGS FOR RAILROADS. By F. M. Waring, in *Proceedings* of American Society for Testing Materials, No. 22, page (1922).

The sulphur and phosphorus limits are set at 0.05 and manganese at 0.85 per cent and the physical properties are discussed.

SELECTION OF STEEL FOR COLD FORGING. By John B. Frederick, in *Forging and Heat Treating,* March, 1923, page 161.

This article discusses the materials best fitted for cold forging operations. It gives the cause of woody fractures of cold headed cap screws and states that annealing may be used to remedy this condition..

CUPOLA MALLEABLE PRODUCTION. By C. C. Hermann, in *Foundry* #50, (1922).

This article states that in manufacturing malleable iron, the cupola process is the cheapest and most economical, and discusses the various kinds of scrap used.

CONVERTER MAKES BETTER STEEL. By R. Burke, in *Foundry* #50, page 915, (1922).

This article states that the purity of the material and the absence of oxides in the finished blow are depended upon for the successful operation of the converter.

MANUFACTURE OF ALLOY STEEL FOR AIRPLANE SHAFTS. By E. Kothny, in *Chemical and Metallurgical Engineering,* #27, page 1020, (1922).

This article gives an explanation of the manufacture of nichrome steel in the Heroult furnace, and also gives a method of manufacturing alloy steel for airplane shafts. It further states that it is important that very good raw material be used.

CUTTING METALS WITH THE ELECTRIC ARC. By A. M. Candy, Westinghouse Electric & Manufacturing Company, in *Iron Age,* April 19, 1923, page 1098.

In this article the author gives the hourly rate and the cost of cutting the metals. The use of various methods for scrapping discarded steel freight cars is discussed.

Reviews of Recent Patents

1,439,454. Art of Treating Castings. W. Y. Stroh, Pittsburgh, Pa., and J. Thompson, Oakmont, Pa., assignors to Catherine Strayer, Pittsburgh, Pa.

This patent covers an article of manufacture, a casting having a finished and polished surface produced directly upon the surface of the casting solely by the action of a series of hammer blows.

1,439,972. Electric Arc Welding. P. O. Noble, Schenectady, N. Y., assignor to General Electric Co., a corporation of N. Y.

An arc welding machine employing a fusible electrode, the combination with means adapted to feed the electrode to the work to be welded, and a means for conducting a fusing current to the electrode, and a means for applying a coating or covering of liquid material to the electrode as the latter is fed to the work to be welded.

1,439,865. Nickel Alloy. Leon Cammer, N. Y. C., assignor to the International Nickel Co., a corporation of N. J.

This patent comprises an alloy of nickel, copper and aluminum, wherein the content of nickel is in excess of 50 per cent and the content of aluminum is not less than about 3 per cent and not more than 17 per cent, the predominant metal of the remaining content being copper.

1,440,470. Method and Apparatus for Testing Welds. Isaac F. Kinnard, Wilkinsburg, Pa., assignor to Westinghouse Elec. & Mfg. Co., a corporation of Pennsylvania.

This invention relates to a method of testing welds which comprises passing electrical energy through a weld to be tested and comparing the character of the energy passing through the weld to that passing through the body of the material.

1,440,724. Electrode for Electric Furnaces and Process for Manufacturing the Same. Carl Wilhelm Soderberg, Christiania, Norway, assignor to Det Norske, Aktieselskab for Elektokemisk Industri, Chistiania, Norway.

This relates to a process of manufacturing electrodes for electric furnaces, which comprises tamping raw electrode mass into a metallic mantle constituting a part of the electrode and which is provided with projections extending into the electrode mass, and passing electric current through the mantle whereby heat is generated and distributed into the interior of the electrode mass and baking the latter is thus effected.

1,440,546. Furnace. Frederick C. Langenberg, Watertown, Mass., and John F. Fetterly, Altoona, Pa., assignors to the Surface Combustion Co., Inc., New York city a corporation of New York.

This invention refers to a furnace which is composed of a heating chamber, a diaphragm extending inwardly from the wall of said chamber and having an inner edge adapted to extend close to the surface of the object to be treated, and means for supplying heat to the zones formed in said chamber by said diaphragm, whereby a desired temperature may be maintained in each zone.

1,440,446. Furnace Roof. Walter H. Cotton, Chicago, Ill.

This relates to a furnace roof which comprises a course of brick consisting of a plurality of independent abutting sections, each section being composed of a plurality of interlocking brick and a supporting hanger for each section.

1,440,468. Sectional Furnace Roof. Abraham L. Kanagy and Walter H. Cotton, Chicago, Ill.

This refers to a sectional furnace roof which is composed of a plurality of sections each consisting of a pair of beams having projecting ledges, a plurality of brick having projections complementary to and resting on said ledges, and means for holding the beams in parallel relation.

1,440,540. Method of and Apparatus for Heat Treatment. William J. Harris, Jr., New York city, assignor to the Surface Combustion Co., Inc., a corporation of New York.

This invention relates to a method of heat treatment as well as an apparatus for the same. The method consists of heating different zones of an article under treatment to different temperatures while securing a uniform heating around the periphery of each zone of the article, which surrounds the article with a body of gases, causing said body of gas to whirl about the article in planes perpendicular to the axis of the article, and maintaining the gases whirling about one zone of the article at a temperature different from the gases whirling about another zone of the article.

The apparatus is composed of an outer cylindrical wall, an inner wall into an annular combustion chamber and a cylindrical treating chamber, and means for causing combustion in said combustion chamber and for causing a whirling of the burning gases in said combustion chamber, said inner wall being provided with passages adapted to direct the whirling gases from the combustion chamber into the heating chamber and cause them to continue their whirling motion in the treating chamber.

1,440,619. Process of Cleaning and Surfacing Sheet Steel. Samuel M. Noyes and Samuel Peacock, Wheeling, W. Va.

This refers to a process of cleaning and surfacing sheet steel containing cementite and ferrite in its surface which consists in mechanically removing said cementite leaving channels in the ferrite; and mechanically spreading said ferrite over said surface to fill said channels and inhibit the subsequent oxidation of said surface, substantially as described.

1,440,657. Highly-refractory Article and Method of Producing the Same. Henry H. Buckman, Jacksonville, Fla., and George A. Pritchard, New York city, assignors to Buckman & Pritchard, Inc., Jacksonville, Fla., a corporation of Florida.

This patent describes a new article of manufacture which is a highly refractory material containing zirconia and also silica.

1,441,479. Process for Making an Alloying Alloy. Wilson Bennett, Wellington, New Zealand.

This invention relates to a process of producing an alloying alloy which consists in mixing chromium ores with ore reducing agents in an electric furnace, passing an electric arc through the mixture to reduce and refine the metals, removing the resulting slag, adding a decarburizing mixture including a high content of silicon to the remaining metals and passing a current through the mass to reduce the carbon to a low percentage and to eliminate excessive chromide oxide losses during the decarbonization, and removing the resulting slag.

1,442,444. Casting High-melting-point Metal. Howard T. Reeve, East Orange, N. J., assignor to Western Electric Co., Inc., New York city, a corporation of New York.

This refers to a method of obtaining high melting point metals and alloys in the form of rods of small diameter which consists in forcing the molten material into a tube of refractory material, allowing it to cool therein and separating the material from said tube.

News of the Chapters

SCHEDULED REGULAR MEETING NIGHTS

FOR the convenience of visiting members, those chapters having regular meeting nights are listed below. It is desired that all secretaries whose chapters are not included in the list should communicate with the National Office in order that the list may be as complete as possible.

Boston—Second Tuesday
Bridgeport—Thursday between 20th and end of month
Chicago—Second Thursday
Cincinnati—Second Thursday
Cleveland—Fourth Friday, Cleveland Engineering Society Rooms, Hotel Winton; meeting at 8:00 p. m.
Detroit—Second and fourth Monday, Wing E., 15th Floor General Motors building.
Hartford—Friday nearest 10th of month
Indianapolis—Second Monday
Lehigh Valley—No regular night
New Haven—Third Friday
New York—Third Wednesday
Philadelphia—Last Friday
Pittsburgh—First Tuesday
Providence—No regular night.
Schenectady—Third Tuesday
Springfield—Third Friday
South Bend—Second Wednesday
St. Louis—Third Monday
Syracuse—No regular night
Tri City—Thursday
Washington—Third Friday
Rockford—Second Friday following the second Thursday

MEMBERSHIP AND ATTENDANCE CONTEST

While last month it was observed that four chapters had an increase of over 50 per cent in membership, there are six chapters for the present month that are above the half-hundred mark. In fact, three of them have very nearly doubled in membership. However, this percentage does not represent all new members but also represents the bonus received for new sustaining members.

It will be observed that Cincinnati jumped from eleventh to third place. This is due largely to the fact that Dr. J. Culver Hartzell, the chairman, went out personally and single-handed, obtained ten new sustaining memberships, returning the same to this office with his check for $250.00. In this connection

it is interesting to note that the National Office returned to the Cincinnati Chapter $187.50 of this amount.

The following arrangement of the chapters shows the percentage of net increase of new members as of April, 1923, based on the number of members each chapter had on September 1, 1922.

	Per Cent		Per Cent		Per Cent
1. Tri City	98.8	10. Syracuse	38.2	19. Indianapolis	17.8
2. South Bend	92.0	11. Lehigh Valley	36.1	20. Washington	17.5
3. Cincinnati	83.2	12. Schenectady	29.4	21. Chicago	16.4
4. Detroit	67.6	13. Hartford	22.8	22. Pittsburgh	14.0
5. North West	54.3	14. Buffalo	22.5	23. St. Louis	10.5
6. Philadelphia	50.6	15. Cleveland	22.1	24. Springfield	10.3
7. New Haven	42.5	16. New York	21.6	25. Worcester	8.9
8. Milwaukee	42.2	17. Toronto	21.4	26. Providence	5.3
9. Boston	40.9	18. Rockford	18.7	27. Rochester	4.8

Attendance at March Meetings

Only 16 chapters reported attendance at March meetings. There are other chapter meetings, reports of which did not reach the office that were held late in the month. No attendance report was received from the following chapters: Boston, Buffalo, Chicago, Hartford, Indianapolis, Lehigh Valley, Rochester, Schenectady, Toronto, Washington and Worcester.

The following gives the percentage of attendance at March meetings. Those chapters printed in CAPS show an increase in percentage of attendance over that of the February meeting:

	Per Cent		Per Cent		Per Cent
1. NEW HAVEN	69.7	7. ST. LOUIS	38.5	13. Milwaukee	26.0
2. SOUTH BEND	69.2	8. DETROIT	35.1	14. Cleveland	21.6
3. TRI CITY	60.7	9. CINCINNATI	31.8	15. Pittsburgh	14.6
4. Providence	45.7	10. North West	30.0	16. New York	11.2
5. Syracuse	44.8	11. Philadelphia	29.0		
6. SPRINGFIELD	38.9	12. Rockford	27.5		

Standing of the Chapters in Contest

In order to determine the standing of each chapter in the contest it is necessary to add the percentage of attendance at the December, January, February and March meetings and divide by four to determine the average attendance for the four meetings. The average thus obtained is added to the percentage of net increase obtained since Sept. 1, 1922 to March 31, 1923. This total is then divided by two to obtain the standing of each chapter in the contest inasmuch as attendance counts 50 per cent and increase in membership 50 per cent.

On this basis we find the following to be the standing of the chapters on April 1, 1923, in the Membership and Attendance contest:

	Per Cent		Per Cent		Per Cent
1. Tri City	74.3	8. Philadelphia	41.1	15. Washington	24.4
2. South Bend	73.8	9. Milwaukee	35.9	16. Springfield	23.1
3. Cincinnati	53.7	10. Boston	32.8	17. Cleveland	22.3
4. New Haven	47.5	11. Providence	31.0	18. Chicago	18.7
5. Detroit	46.9	12. Rockford	29.2	19. New York	18.7
6. North West	45.1	13. Hartford	28.2	20. Indianapolis	17.8
7. Syracuse	43.5	14. St. Louis	28.0	21. Pittsburgh	14.9

In this connection it is interesting to note that there are two new faces among the leaders—Cincinnati and New Haven. Cincinnati jumped

from the fourteenth place in the contest to the third, and New Haven from ninth to fourth. The contest for first place is still quite sharp between Tri City and South Bend and reverses the standing as of February when South Bend was first and Tri City second.

There is no reason whatever for any of the other chapters becoming discouraged—as an example, the advancement of Cincinnati is possible for one chapter as well as for another. The only thing required is a little time and the selection of the proper individuals to call upon the manufacturing firms in your territory and secure from them the co-operation your chapter deserves.

Based on the number of members in each chapter on April 1, 1923, the following table shows the standing of the twenty-seven chapters of the Society. Those printed in CAPS have advanced their position while those that are in _italics_ have a lower position than that occupied in the previous report:

1. Detroit	10. *Syracuse	19. SOUTH BEND
2. Chicago	11. *Lehigh Valley	20. _Washington_
3. PHILADELPHIA	12. *North West	21. _Buffalo_
4. _Pittsburgh_	13. *Tri City	22. NEW HAVEN
5. Cleveland	14. *Worcester	23. *_Schenectady_
6. New York	15. *CINCINNATI	24. *Providence
7. Hartford	16. *_St. Louis_	25. _Springfield_
8. MILWAUKEE	17. *_Indianapolis_	26. Toronto
9. _Boston_	18. _Rockford_	27. Rochester

*Tied

MEETING AT MUNCIE, INDIANA

Marcus A. Grossmann, chief metallurgist with the Atlas Steel Corporation, Dunkirk, N. Y., addressed over three hundred men interested in iron and steel at a meeting held in the main auditorium of the Central high school at Muncie, Ind., on Monday evening, April 16.

The address was given under the auspices of the department of industrial education in charge of Glen D. Brown, director.

The Muncie city schools are indeed fortunate in having such an adequate and complete industrial department and has for some time maintained an enviable reputation among high schools of the country for the wonderful co-operation it has given in catering to the needs of the industries of their vicinity, consequently it was not unusual that they should have this meeting of men interested in iron and steel due to the fact that over forty-four industries in their thriving business district are engaged in the fabrication of steel.

The close proximity of the cities of Anderson and Newcastle to Muncie makes the territory all the more vitally interested in the subject Mr. Grossmann discussed and all of these influences increased the attendance at the meeting.

The meeting was opened by Director Brown, acting as temporary chairman, who turned the meeting over to W. H. Lyman, superintendent of the Warner Gear Company, of Muncie.

Mr. Lyman outlined briefly the work of the industrial department of the high school and congratulated those present upon the high caliber of the work carried on and the wonderful aid that the department was to the local industries.

Mr. Lyman introduced Vere Sutton, superintendent of the Muncie Prod-

ucts division, General Motors Corporation, Muncie, who acted as permanent chairman and introduced the speaker of the evening.

The subject of Mr. Grossmann's talk was "The Electric Furnace and Crucible Practices in the Manufacture of Steel." He handled the subject in a very interesting and entertaining manner, illustrating many of the important operations with moving pictures.

At the close of Mr. Grossman's remarks, W. H. Eisenman, national secretary of the A. S. S. T., was introduced and outlined briefly the aims and accomplishments of the society·

Mr. Sutton made the statement that the cities of Anderson, Newcastle and Muncie might consider seriously the organization of a chapter of the A. S. S. T. in case there was sufficient interest manifested by the manufacturers and interested men in that locality.

A number of other gentlemen representing various cities and industries discussed the advisability of the establishment of a local chapter at this time and then upon motion duly made and seconded it was decreed that Mr. Sutton should appoint a committee to thoroughly canvas the situation and to report at a future meeting as to the advisability of organizing a chapter in that territory to include the cities of Muncie, Anderson and Newcastle.

BOSTON CHAPTER

The Boston chapter of the American Society for Steel Treating held its regular monthly meeting on April 18, at 3 p. m. at the plant of the Waltham Watch Company, Waltham, Mass.

The program for this meeting was a trip through the plant of the Waltham Watch Company. Following the inspection of the plant members and guests assembled at the Adams House, Waltham, where an informal dinner was served at 6:30 p. m.

Following the dinner the meeting adjourned to the Riverside club of the Waltham Watch Company for a social hour, at which time A. J. Erickson, foreman of the machine shop, presented a paper entitled "Heat Treating Problems in Watch Making."

Mr. Erickson brought out many points pertaining to the heat treatment of small parts for watches, especially that of springs.

Following this paper the motion picture entitled "The Story of Alloy Steel," which was produced by the United States bureau of mines, was exhibited.

This meeting proved to be highly successful and of extreme interest to all who had the privilege of attending.

BUFFALO MEETING

The Buffalo chapter of the American Society for Steel Treating held its regular monthly meeting on April 24, at 8:00 p. m., in the Hotel Statler.

The Buffalo chapter was very fortunate in obtaining as speaker for this meeting, C. G. Armstrong, of Chicago, who presented an interesting and worthy paper entitled, "Steel Treating Furnaces."

Mr. Armstrong reviewed with considerable detail the various designs of steel treating furnaces and their application to the various types of treating.

He discussed the various types of fuels that are used in the heat treatment of steel, bringing out many points of information relative to the efficiencies and adaptability of many fuels available.

The subject of furnaces and refractories has always been a matter of keen interest to steel treaters, inasmuch as good uniform treatment can only be accomplished through the uniform application of heat to the parts and in turn this uniform application can only be accomplished through the proper design and construction of the furnaces combined with the proper type of burners and the proper type of fuel.

Following the presentation of this paper a long and interesting discussion was held on the subject of furnaces and fuels.

The meeting was well attended by many of the members of the Buffalo chapter and their guests.

At 6:30 p. m., the usual get-together dinner was served to a good sized number of members and guests.

All in all this meeting was a very successful one.

CHICAGO CHAPTER

The regular April monthly meeting of the Chicago chapter was held at the City club, 315 Plymouth court, on the twelfth of April, 1923.

The usual get-together dinner was served at 6:30 p. m. and the regular meeting followed at 8 p. m.

The Chicago chapter was favored by a very interesting paper presented by O. T. Muehlemeyer, metallurgist of the Barber Colman Co., Rockford, Ill., on the subject of "Hardening Room Practice."

Mr. Muehlemeyer, who is a very capable metallurgist, having successfully operated some of the largest heat-treating plants in this country, presented some very interesting and valuable data in reference to his subject.

Following the presentation of this paper, a very interesting and helpful discussion ensued.

The Chicago chapter had a very large turnout for this meeting, which proved to be a decided success.

CINCINNATI CHAPTER

On Thursday evening, April 12, the Cincinnati chapter of the American Society for Steel Treating, held its regular monthly meeting at the Ohio Mechanics institute, Canal and Walnut streets.

The chapter was very fortunate in having as their speaker Major F. F. McIntosh, professor of metallurgy at the Carnegie Institute of Technology, Pittsburgh, Pa., who presented a very capable paper entitled "The Application of Alternating Stress Tests to Industrial Problems."

In addition to his affiliation with the Carnegie Institute of Technology, he is consulting metallurgist for several of the largest Pittsburgh steel companies and other Pittsburgh corporations. During the war Major McIntosh was in the inspection division of the ordnance department and did much very valuable work. He has had many years' experience in the testing and inspection of steel and steel products, and as a result presented some very interesting information for both practical and technical men.

CLEVELAND CHAPTER

The Cleveland chapter of the American Society for Steel Treating

held its regular April monthly meeting Friday evening, April 27, at 8:00 p. m., in the Cleveland Engineering society rooms, Hotel Winton.

The program for this meeting was a paper by Dr. Paul D. Merica, director of research of the International Nickel Co., New York City, entitled "Nickel, Its Metallurgy and Uses."

Dr. Merica, who is a nationally known metallurgist in this country, formerly associated with the United States bureau of standards, has done a vast amount of work on metallurgical subjects, both ferrous and non-ferrous. His experience has been very broad, both along research lines and practical lines and as a result his paper was very interesting both to the technical man and the shop man.

He reviewed in considerable detail the properties of nickel and its application to the many phases of the industry, both as pure metallic nickel and as it is alloyed with other elements.

The paper was illustrated with stereopticon slides and proved to be very interesting.

A lively and interesting discussion followed Dr. Merica's presentation.

A very large turn-out of Cleveland members and guests was had at this meeting.

The usual get-together dinner was served at 6:30 p. m.

DETROIT CHAPTER

The Detroit chapter of the American Society for Steel Treating held its first meeting for the month of April, Monday evening, the ninth, at 8 p. m. in the east wing of the fifteenth floor of the General Motors building, Detroit, Mich.

The speaker for this meeting was H. F. Wood of the Ingalls-Shepherd division of the Wyman-Gordon Company, Harvey, Ill., who presented a very capable paper entitled "Management of Heat Treating Departments and Determination of Heat Treating Costs."

For a number of years back Mr. Wood has been intensively studying the items of cost in respect to the heat treatment of steels, and he presented a very capable paper on this subject, discussing many of the points which ordinarily are more or less difficult to determine. The problem of determining costs involves a wide range of items and it is only through careful study and collection of data that accurate costs can be ascertained. Determining overhead charges and depreciation have always caused a great deal of trouble in arriving at proper and correct costs. Mr. Wood developed a very logical plan for handling these two items of cost finding.

Inasmuch as Mr. Wood's company is devoted entirely to the forging and heat treating of materials on a large scale they have been able to make exhaustive tests and investigations to determine their thermal and power efficiencies.

Following the presentation of Mr. Wood's paper a very interesting and lively discussion ensued.

On Monday, April 23, the Detroit chapter held its second monthly

meeting for the month of April in the east wing of the fifteenth floor of the General Motors Company.

This meeting, as in the case of the former meeting, was preceded by the regular get-together dinner which was served at 6:30 p. m. in the meeting room.

The speaker for this second monthly meeting was H. G. Peebles, metallurgist of the Detroit Steel Products Company, who presented an illustrated paper entitled "The Manufacture and Inspection of Springs."

Mr. Peebles has had many years' experience in the manufacture and inspection of springs and presented a very capable and interesting paper.

Mr. Peebles handled his subject in a very capable manner and an interesting and profitable discussion followed its presentation.

Both of these April meetings were very well attended.

HARTFORD CHAPTER

The Hartford chapter of the American Society for Steel Treating held its regular monthly meeting on Friday evening, April 13, at 7:45 in the assembly hall of the Hartford Electric Light Company, Pearl street, Hartford, Conn.

Two speakers were scheduled to address this meeting. They were J. H. Coffey and C. M. Blackman.

Mr. Coffey presented many of his experiences during a half century of service in the forging and heat-treating departments of the Pratt & Whitney Company, and Mr. Blackman related some of the things that make life interesting for him in the heat-treatment room of the Colt Manufacturing Company.

Both of these gentlemen related many of the interesting problems that they have encountered and the manner in which they were solved.

Following the two talks the following questions were presented for discussion. These questions had been included on the regular announcement of the meeting, so that all members had the opportunity of reviewing them prior to the meeting with the result that a great many valuable points of information were developed.

1. In quenching steel does it expand or contract? What are the conditions governing its action?
2. What are the causes, and what are the best conditions for shrinking holes in tool steel?
3. How may warpage be overcome in long slender tools? Are quenching fixtures applicable to such work?
4. What is the best method of preventing cracking through holes in blanking dies, etc?
5. Which quenching medium will produce the greatest depth of hardening and the greatest hardness, oil, water, or brine?
6. Can high carbon chrome ball steel be quenched from 1650 degrees Fahr. into brine without cracking?
7. What is the result of the following treatment? Heat ball steel to 1500 degrees Fahr., remove and place in another furnace at 1250 degrees Fahr., cool to furnace temperature, then quench.
8. What is the best method of preventing carburization in holes, or in the bore of parts to be case hardened?
9. Can satisfactory cutting tools be made by case hardening soft steel?
10. What are the requirements for a good spindle, hardness, etc? How obtained?
11. Burnishing tools—Why do some burnishing tools used in the silver

industry "pick up" emery, while others, apparently the same, do not?

12. What is the best way to harden "non-shrinking" tool steel?
13. What are the relative importance of "brand" and "composition" in the purchase of tool steel?
14. Can cracks be produced in sound hardened steel by grinding? Can hardened steel be softened by the grinding operation?
15. What causes black fractures in tool steel?
16. Which furnaces are most economical for heat treatment, over-fired or under-fired?
17. Are electric furnaces suitable for heat treatment where freedom from scale is an important factor?
18. Can a reducing atmosphere in a furnace cause decarburization and result in softness after quenching?
19. What is the value of the deep etch, and what are its shortcomings?

This meeting proved to be highly successful and much valuable information was disclosed.

The usual informal get-together dinner was served at the Bond hotel at 6:30 p. m., preceding the meeting.

INDIANAPOLIS MEETING

The Indianapolis chapter staged one of its old-fashioned, good-natured, well-attended chapter meetings at the Missouri Athletic club on Tuesday evening, April 17, when Marcus A. Grossmann, chief metallurgist with the Atlas Steel Corporation, Dunkirk, N. Y., and national secretary, W. H. Eisenman, were present.

Over one hundred members were in attendance to hear Mr. Grossmann, who gave a very interesting and detailed description of the processes of making steel by the use of the crucible and electric process.

Mr. Grossmann is an authority on the manufacture of steel and the freedom with which he spoke on mill practices and the reasons for various operations proved to be quite interesting and highly educational.

Quite a lively discussion took place upon the completion of Mr. Grossmann's paper and was entered into with a hearty spirit and was highly satisfactory.

Chairman Deeds then introduced the national secretary, who outlined briefly the accomplishments and the ambitions of the A. S. S. T. as well as reporting the progress the society made last year.

The nominating committee made their report of officers to be elected at the May meeting and after various other committee reports and matters of general interest a buffet luncheon was served by the Athletic club. This luncheon was quite a factor in adding to an already enjoyable and pleasant social evening.

EDUCATIONAL COURSE AT INDIANAPOLIS

The Indianapolis chapter has every reason to be proud of the very successful results that have been accomplished by the course conducted by the chapter at the Manual Training high school in Indianapolis.

For some time there has apparently been a demand on the part of the industries in the vicinity for some course dealing with the fundamentals of metallurgy to which those who aspired to a greater understanding of the processes of science might have an opportunity to acquire this information.

In order to meet this demand the local chapter under the chairmanship of Mr. Deeds rose splendidly to the occasion and early in the fall got to-

gether one hundred and fifty members of the chapter and men in the manufacturing industries of the city, at which meeting the general problems and conditions of the course were investigated.

It was learned that the facilities of the Manual Training high school would be available for the use of the class through the courtesy of their efficient principal, Mr. McComb.

In order that any course on the fundamentals of metallurgy may be a success it is necessary that it should have a director invested with the sole responsibility and the selection of this individual was the next problem that confronted the chapter. However, the chapter had little difficulty in solving this momentous problem due to the presence in their organization of H. B. Northrup, chief metallurgist of the Diamond Chain Company and vice-chairman of the Indianapolis chapter.

Mr. Northrup was for a number of years engaged in the teaching of metallurgy at Penn State college, and besides his valuable experience in war work, had had an extensive practice in the practical side of metallurgy.

Mr. Northrup kindly consented to undertake the work of the preparation and shaping up of this course and the chapter set about to secure the enrollment of the proper number of individuals. A letter was prepared and sent out to all manufacturing firms informing them of the approaching course and suggesting that inasmuch as thousands of dollars were lost each year due to faulty heat treatment that they should be particularly interested in having their men enroll as members of this course.

The manufacturing industries of Indianapolis responded splendidly to this notice and many of them even went so far as to state that in case the men in their employ should enroll in the course and pay the charge of $6.00, they would be pleased to reimburse their employes provided they attended 75 per cent of the lectures.

Consequently, on December 8, the first organization meeting of the night course was held and sixty men enrolled to take the course of fifteen weeks.

It was decided to hold the meetings regularly each week on Monday evening and the regular course began immediately after the holidays and has continued successfully through to the present time with but two more lectures to be held.

As previously stated, the lectures are held at the Manual Training high school and the equipment used in the course has been furnished by the local industries; the furnace having been donated by the Imperial Drop Forge Co. The lectures are held in the evening and are of two hours duration, starting at 7:30 and closing at 9:30 p. m.

One of the most remarkable instances in connection wth this course has been the constant attendance, which has been due to several reasons, probably the most important of which is the able direction of the director of the course in making his lectures and those who contributed special lectures of such interest and upon such vital subjects that the men have developed a decided interest in the lectures and are conscious of the benefits they are able to obtain.

The greater number of lectures have been delivered by principal Northrup, although G. F. Atkins, of the E. C. Atkins & Co., delivered one lecture on the subject of "Quenching in the Hardening Range," while H. W. Hayward of the Link-Belt Co., gave a paper and demonstration on the subject of "Testing For Physical Properties." The class was taken to the Link-

Belt physical laboratories where Mr. Hayward demonstrated the uses of various testing apparatus.

Paul Deeds, metallurgist at the Indianapolis Tool and Manufacturing Co., gave a very interesting and instructive lecture on "Carburizing Practices," while Professor John Keller, head of the extension department of Purdue university, gave a lecture on "Why Steel Warps," and also "The Selection of Steel by Means of the Spark Test." The lecture by Mr. Grossmann before the regular meeting of the chapter also served as supplementary information to the members of the class on the manufacture of steel by the crucible and electric process.

The general outline of the lectures in the course in metallurgy presented by Mr. Northrup, is as follows:

I. Historical. Outline of the development of the iron and steel industry.

II. Iron Ores. A study of the principal ores of iron with especial reference to the metals and metalloids which are inherent in the ore and traceable directly into the finished product.

III. The Iron Blast Furnace. A study of the evolution of the present day furnace and the effect of furnace design upon the quality and quantity of the resultant metal.

IV. Blast Furnace Fuels, Fluxes and Refractories.

V. Modern American Blast Furnace Practice.

VI. Effect and Control of the Elements Entering Into Pig Iron.

VII. The Manufacture and Some of the Uses of Wrought Iron and Crucible Steel.

VIII. Bessemer Steel, Its Manufacture and Adaptability.

IX. Open Hearth Steel. Methods of manufacture and some of its commercial applications.

X. Definitions and Terms. Cast iron. Pig iron. Gray cast iron. White cast iron. Malleable cast iron. Steel. Wrought iron. Ferrite. Cementite. Pearlite. Sorbite. Troostite. Martensite. Austentite. Normalizing and Normal Structure. Annealing and Annealed Structure.

XI. Effects of the Added Elements on Steel. Effects on its physical properties and upon the thermal critical points as effecting heat treating.

XII. Heat Treatment. The Iron-Carbon diagram. Causes of the thermal critical points in iron and steel. Changes which take place at the various critical points.

XIII. Temperature Measurement. Instruments used, their application and calibration.

XIV. Carburizing. Materials used and their selection. Carburizing practice.

XV. Physical Testing. Machines and methods used. Definitions and terms used. Explanation of the correlation between heat treatment and physical properties.

The results of the course this year have been so satisfactory that there is a demand that the course be repeated next year and it is probable that this will be done.

One of the most encouraging features of the entire work has been that the attendance at the meetings has been 75 per cent of the enrollment.

The Indianapolis chapter, both collectively and individually, and especially

those who have been directly in charge of this work, have contributed a very valuable piece of work to the industries served by the local chapter and their record will be one that will be looked upon as a wonderful service by the American Society for Steel Treating to the industries it serves.

LEHIGH VALLEY CHAPTER

On Friday evening, April 27, at 8 p. m., the Lehigh Valley chapter of the American Society for Steel Treating held a meeting at the Engineers' club, Reading, Pa., at which time F. O. Kichline, engineer of tests at the Bethlehem Steel Company's Lebanon plant presented a paper entitled "The History of the Iron and Steel Industry in Eastern Pennsylvania."

Mr. Kichline's presentation was very interesting, and especially so to the members of the Lehigh Valley chapter, inasmuch as his paper covered much of the history in the immediate vicinity of Bethlehem and Reading.

This meeting was well attended and proved to be a decided success.

MILWAUKEE CHAPTER

The Milwaukee Chapter of the American Society for Steel Treating held its regular April monthly meeting Tuesday evening, April 17th, at 8:00 p. m., at the Blatz Hotel, East Water and Oneida Streets, Milwaukee, Wis.

The speaker for this meeting was Jerry Burns, of the E. F. Houghton & Co., who presented a paper entitled "Quenching Media." Much valuable information was disclosed by Mr. Burns in his paper and the members of the Milwaukee Chapter felt fully repaid for their attendance at this meeting.

The selection of the proper quenching medium is a very vital factor in the proper heat treatment of steels and one which deserves more attention than it has had in the past.

This meeting was especially well attended and as evidenced by the large amount of interesting discussion which followed the presentation of the paper of the evening, the meeting was a decided success.

NEW HAVEN CHAPTER

The New Haven chapter of the American Society for Steel Treating held a meeting on Friday evening, April 20, 1923, at 8 p. m. in the assembly room of the New Haven Gas Light Company, 70 Crown street, New Haven, Conn.

Dr. Paul D. Merica, metallurgist with the International Nickel Company, was the speaker for this meeting. The subject of his paper was "The Metallurgy and Uses of Nickel and Nickel Alloys."

Dr. Merica, formerly with the U. S. bureau of standards, has done a vast amount of metallurgical work and is an authority on the subject of alloy steels, especially those of nickel.

Dr. Merica presented his paper in a very capable manner and brought forth many valuable points of interest and information.

Following the presentation of his paper a very valuable and interesting discussion ensued.

This meeting was very well attended and proved to be a decided success.

NEW YORK CHAPTER

The New York chapter of the American Society for Steel Treating held its regular April meeting on Wednesday evening, the eighteenth, at 8:15 p. m. in the assembly room of the Merchants Association of New York, ninth floor, Woolworth building, New York city.

The program for this meeting was a paper by C. H. Wilson, of the Wilson-Maeulen Company, entitled "Some Practical Considerations in the Use of Pyrometer Thermocouples."

Mr. Wilson illustrated his paper by means of blackboard sketches and brought out many points with reference to pyrometers, and pyrometer thermocouples and apparatus used in the determination of temperature in the heat treatment of steels.

Mr. Wilson developed his subject in a very interesting and entertaining manner and brought out many points that clarified some of the misunderstandings and misconceptions in the use of thermoelectric heat measuring devices.

Following the paper a general round-table discussion on pyrometry was held, with the general consideration of such questions as "What is the matter with my pyrometers?" This discussion brought out many interesting points and was participated in by a large number of the members of the New York chapter.

The meeting proved to be highly successful and of benefit to all.

The usual get-together dinner was served at 6:30 p. m. at the Post Keller restaurant of the Woolworth building.

NORTH WEST CHAPTER

At the meeting of the North West chapter Wednesday evening, March 28, William I. Sweet, of the Auto Engine Works, St. Paul, spoke upon the "Heat Treatment of Certain Motor Parts." He discussed the best methods of hardening pistons, crankshafts, connecting rods, piston wrist-pins, camshafts, valve tappets, main bearing-bolts, connecting rod-bolts, clutch cones, various gears and steel casting parts.

Mr. Sweet also demonstrated the spark test for identifying different grades of steel, which was illustrated by low carbon steel, medium carbon steel, high carbon steel, different kinds of alloy steels, and cast iron.

The talk was well received and brought forth considerable discussion. The members felt that they could make practical application of the spark test in their plant practice for identification of different kinds of steel.

Mimeographed briefs covering Mr. Sweet's presentation of the subject were dstributed to all members present so that they might have a permanent record of what is considered and recognized as standard practice for the heat treatment of certain parts. Blue prints together with descriptive material of the spark tests were also distributed.

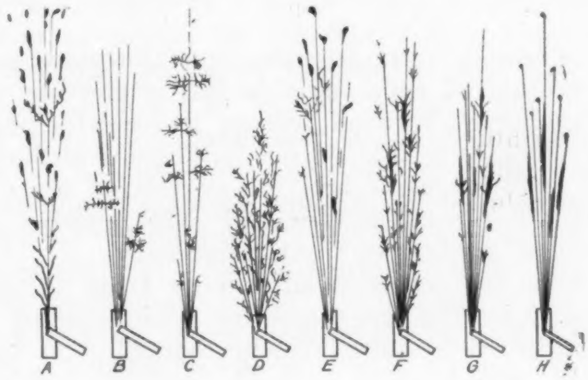
For the benefit of other members of the society the following is a reproduction of the spark test data distributed to the North West chapter members.

The following descriptions refer to the accompanying sketch which shows the characteristic sparks of different steels as thrown off by a grinding wheel. Briefed by Mr. Sweet.

Fig. A represents the spark as thrown from a special steel manufactured and to be used especially for magnets. It clearly demonstrates the advantage of this method of selecting steels by comparison; in other words, mark your favorite brands or grades and compare them with others. By practicing this method, there will be fewer taps and reamers made out of machinery steel, with

a corresponding decrease of forgings made out of metals that are too high in carbon. Touch the material lightly on wheel, observe individual sparks.

Fig. B is Mushet steel. This grade of air hardening or high-speed steel, is very easy to distinguish from other steels as the particles follow a broken line and are a very, very dark red, with an occasional manganese spark.



Manganese in tool steel above a certain per cent is a very injurious element. The characteristic of the manganese spark, Fig. C, is that it widely differs from the carbon spark in that it seems to shoot or explode at right of angles from its line of force. Each dart is subdivided into a number of white globules. With a little practice, the trained eye will soon detect the slightest trace of manganese in the iron or steels.

In the higher grades of carbon steels, the iron lines are practically eliminated, with an increase of the star-like explosions, Fig. D, which often divide and subdivide, causing a beautiful display of figures. This is probably due to the iron and carbon becoming so united that they are most easily attacked by the oxygen. Hence, the great danger of burning steel in the fire. It would be well to state that the higher the percentage of carbon, the more profuse the explosions and the shorter the distance from their source of heat.

Chromium and tungsten high-speed steels are very easily determined by the spark test. The particles seem to follow a broken line with a very slight explosion; just before they disappear the color is of chrome yellow; and shows no trace of a carbon spark, Fig. E.

In the lower grades of tool steel, which contain from 0.50 to 1.00 per cent carbon, the iron lines become less and less conspicuous, the forking of the luminous streak occurring very much more frequently, often subdividing; the lower, the less sparks, and further from the source of heat, Fig. F.

In mild steel, which contains a small percentage of carbon, the effect is at once noticeable by a division of forking of the luminous streak. This is owing to the progressive action of carbon which is acted upon by the maximum heat of the iron sparks, which then burning explosively, cause a break in the original heavy lines, Fig. G.

A piece of wrought iron, free from carbon, if held against the emery wheel, the end of the bar will be heated by friction. As the small particles are thrown from the wheel, they will follow a straight line, which becomes broader and more luminous some distance from the source of heat and then disappear as they started. Ths is probably due to the action of the air on the heated particles requiring some time to act. (Touch material lightly on wheel, observe individual sparks), Fig. H.

PHILADELPHIA CHAPTER

The Philadelphia chapter of the American Society for Steel Treating held a special meeting on Wednesday, April 11, 1923, at 8:15 p. m. in the Engineers club of Philadelphia, 1317 Spruce street, Philadelphia, Pa.

The speaker for this meeting was Dr. Zay Jeffries, metallurgist with the Aluminum Company of America, who presented a paper entitled "Hardness of Metals."

Dr. Jeffries is one of our foremost metallurgists in this country and has done a large amount of very valuable and interesting work on the theory and practice of metallurgy, both on ferrous and nonferrous materials.

Although Dr. Jeffries is one of our younger metallurgists, he has done a vast amount of research work and has correlated his own researches and that of many others into well defined and well founded theories, which are daily finding practical application in the industry.

The Philadelphia chapter enjoyed a very large turnout at this meeting and as evidenced by the large amount of interesting discussion following Dr. Jeffries' paper, it is quite evident that all who had the privilege of attending were well repaid.

PITTSBURGH CHAPTER

The Pittsburgh chapter of the American Society for Steel Treating held its regular April monthly meeting on Tuesday evening, April 3, 1923, at 8 p. m., in the Hawaiian room of the William Penn hotel.

The program for this meeting was a paper entitled "The Machinability of Tool Steels," presented by J. V. Emmons, metallurgist with the Cleveland Twist Drill Company of Cleveland, O.

Mr. Emmons has done a vast amount of work on the machinability of tool steels and incorporated in his paper data which he has been collecting for the past eight or ten years.

In his paper, Mr. Emmons brought out many valuable points of information to those who are especially interested in the machining of high carbon and alloy tool steels.

This meeting was exceedingly well attended and proved to be a decided success, as evidenced by the large amount of interesting and valuable discussion which followed the presentation of the paper of the evening.

RHODE ISLAND CHAPTER

The Rhode Island chapter of the American Society for Steel Treating held its regular April monthly meeting on Wednesday evening, the 25th, at 8:00 p. m., in the rooms of the Providence Engineering society, 44 Washington street, Providence, R. I.

The chapter was especially fortunate in having as speaker for this meeting A. H. Kingsbury, metallurgical engineer, at the Atha works, of the Crucible Steel Co. of America, Harrison, N. J., who presented a very interesting and capable paper entitled, "Tool Room Troubles."

Mr. Kingsbury has had charge of the high-speed and carbon steel production of the Crucible Steel Co. for many years. He has had many years practical experience in heat treating of steels as well as having had the opportunity of observing the difficulties of others in the heat treatment of tools.

The speaker handled his subject in an interesting and practical way,

bringing out many points of interest and help to the many members of the Rhode Island chapter who are vitally interested in the heat treatment of tools.

This meeting was well attended and proved to be a decided success.

The March meeting of the Rhode Island chapter was held Friday evening, March 16, 1923 in the rooms of the Providence Engineering society.

R. J. Allen, vice president of the National society was present and addressed the gathering, giving a resume of the work the society is doing.

The topic of the evening was, "What Happens When Steel Is Rolled and Why." Arthur Greene, chief of laboratory of the John Illingworth Steel company was the speaker. He illustrated his points with lantern slides, making the subject very clear and plain to all of the sixty or more members and friends present. After Mr. Greene's paper he was plied with questions on every phase of the manufacture of steel, answering them all very satisfactorily. Altogether, it was a very interesting and helpful meeting.

ROCKFORD CHAPTER

The Rockford chapter of the American Society for Steel Treating held its regular April meeting at the Nelson House on the evening of the thirteenth.

After the usual dinner Chairman Muehlemeyer opened the meeting and the nominations for next year's officers were presented by the nominating committee. Routine business was dispatched and Mr. Whipple, a member of the chapter and general manager of the Rockford Gas Company, a sustaining member, invited the chapter to visit the gas plant in a body, promising a complete sightseeing tour, entertainment and refreshments.

H. F. Wood, chairman of the Chicago chapter, was then introduced and talked on the "Uses and Possibilities of Heat Treatment." This was followed by quite a discussion. The paper was full of real dope (beneficial) and well worth while.

SCHENECTADY CHAPTER

The regular monthly meeting of the Schenectady chapter was held on Tuesday evening, April 3, at 8 o'clock in the Civil Engineering building, Union college.

The chapter was especially fortunate in having for the speaker at this meeting, Lawford H. Fry, metallurgist of the Standard Steel Works, Burham, Pa.

Mr. Fry, who is an authority on the subject of steel and its heat treatment, presented a very interesting and instructive paper entitled "Steel Treating," bringing out many valuable points of interest and instruction to the members present.

Following the presentation of this paper a large amount of interesting and valuable discussion ensued.

SOUTH BEND CHAPTER

The South Bend chapter of the American Society for Steel Treating held its regular monthly meeting April 11 in the number 2 plant of the Studebaker corporation.

The South Bend chapter was especially fortunate in having two speakers for this meeting, the first, J. A. White, of the Clark Equipment Co., Buchanan, Mich., presented a two-reel motion picture entitled "The Electric Furnace in the Steel Foundry." This picture was very interesting and brought out many points of information relative to the use of electric furnaces in the manufacture of steel castings.

The second speaker for this meeting was H. M. Boylston, professor of metallurgy at the Case School of Applied Science, Cleveland, O., who presented a paper entiled "Metallography and Its Application in the Inspection of Steel." Professor Boylston's paper dealt with the various types of photo-micrographic cameras available, also the technique involved in the preparation of specimens of steel for microscopic examination.

This meeting was especially well attended and proved to be a very decided success.

A lengthy discussion followed the presentation of these two papers.

SPRINGFIELD CHAPTER

The Springfield chapter of the American Society for Steel Treating held its regular monthly meeting on Friday evening, March 30, at 8 p. m., in the rooms of the chamber of commerce, 47 Worthington street, Springfield, Mass.

Professor Homerberg presented a paper entitled "The Microscope as an Aid in the Solution of Practical Steel Problems." Professor Homerberg is an expert metallographist and an authority on the subject. His paper was presented without the use of highly technical terms and was illustrated with stereopticon slides.

This meeting proved to be a decided success and developed a large amount of interesting and valuable discussion.

The Springfield chapter of the American Society for Steel Treating held its regular monthly meeting on Friday evening, April 27, at 8:00 p. m., in the Springfield Chamber of Commerce rooms, 47 Worthington street, Springfield, Mass.

Wm. R. Bennett, of Elmwood, Conn., was the speaker for this meeting and presented an interesting and capable paper entitled "Practical Steel Treating." This paper was a non-technical talk by a man who has long been connected with the heat treating business. His many years experience in the heat treating shop especially qualifies him to speak authoritatively on the practical shop viewpoints of heat treating.

Mr. Bennett reviewed the heat treatment of tools, carburizing and the general heat treament of materials.

The Springfield chapter enjoyed a very good turn-out and this meeting proved to be a decided success.

ST. LOUIS CHAPTER

The St. Louis chapter of the American Society for Steel Treating held a meeting on April 16, at which time M. M. Watkins presented a paper entitled, "The Application of Pyrometers, Past, Present and Future," which was illustrated with stereopticon slides. Mr. Watkins handled his paper in a very interesting way, bringing out many points of vital interest to the members concerned.

Well over 35 members and guests were present at this meeting, many of whom participated in the discussion which followed the speaker's paper.

TRI-CITY CHAPTER

The Tri-City chapter of the American Society for Steel Treating held its regular monthly meeting at the Davenport chamber of commerce, Thursday evening, April 26.

Harold F. Wood of the Ingalls-Shepherd division of the Wyman-Gordon Company, Harvey, Ill., presented a very capable paper entitled "The Management of Heat Treating Departments and the Determination of Heat Treating Costs."

Mr. Wood's paper was a very capable treatment of this subject. He has had a number of years of valuable experience in determining costs and handling heat-treating departments and has attacked the problem in a slightly different manner than is ordinarily used.

The item of depreciation has always been rather troublesome to handle and in his paper, Mr. Wood developed a definite procedure in the determination of depreciation based upon his observations and data obtained in past years.

The determination of heat-treating costs is a subject that merits considerable attention and it is sincerely hoped that more of our members will submit their views in paper form.

WASHINGTON CHAPTER

The Washington chapter of the American Society for Steel Treating held a joint meeting with the Washington Academy of Sciences, the Philosophical Society of Washington, and the Washington Society of Engineers on Saturday, March 31, in the auditorium of the Interior building, Eighteenth and F streets, N. W.

The speaker for this meeting was Dr. Walter Rosenhain, of the National Physical Laboratory of Teddington, England, who presented a paper entitled "The Structure and Constitution of Metallic Alloys." Dr. Rosenhain, who is a very eminent metallurgist, has done a vast amount of very valuable research in the study of metallic alloys and has advanced numerous theories as to their constitution.

Dr. Rosenhain has been in the United States for the past two months and has delivered numerous lectures before many of our American engineering and technical societies.

The paper which was presented before this joint meeting proved to be exceedingly interesting and dealt with research methods, apparatus and finally deductions and theories arrived at. Inasmuch as many of our members of the Washington chapter are doing work along this line, Dr. Rosenhain's

lecture proved to be very interesting.

This meeting was very well attended and was a decided success.

On Appril twentieth the Washington chapter held its regular monthly meeting in the auditorium of the new interior department building.

The first part of the program for the evening was a motion picture entitled "The Story of Alloy Steel" prepared by the Interstate Iron and Steel Co. The second part was the exhibition of a film entitled "The Story of the V-Type Eight Cylinder Motor Car" which was prepared by the Cadillac Motor Co. Both of these films were made and furnished through the courtesy of the United States bureau of mines.

This meeting was well attended and proved to be interesting to all.

ADDRESSES OF NEW MEMBERS OF THE AMERICAN SOCIETY FOR STEEL TREATING

EXPLANATION OF ABBREVIATIONS. M represents Member; A repesents Associate Member; S represents Sustaining Member; J represents Junior Member, and Sb represents Subscribing Member. The figure following the letter shows the month in which the membership became effective.

NEW MEMBERS

ADAMS, ROBT. B., (M-3), 2301 E. Vernon Avenue, Los Angeles, Cal.
AHRENS-FOX FIRE ENG. CO., (S-3), Cincinnati, Ohio.
ALLIS-CHALMERS MFG. CO., (S-2) Bullock Works, Cincinnati, Ohio.
AMERICAN HOIST & DERRICK CO., (S-4), 63 S. Robert St., St. Paul, Minn.
AMERICAN PULLEY CO., (S-4), 4200 Wissahicken Avenue, Philadelphia, Pa.
AMERICAN ROLLING MILL CO., (S-3), Middletown, Ohio.
ANDREWS STEEL CO., (S-3), Newport, Ky.
BAKER, JOHN A., (M-3), 3855 Santa Fe Avenue, Los Angeles, Cal.
BARTON, H. J., (A-3), 776 Gladys Avenue, Los Angeles, Cal.
BLACKALL, F. S. JR., (M-4), Taft-Pierce Mfg. Co., Woonsocket, R. I.
BOEHM, GEO. P., (M-4), 2116 W. Oakley Avenue, Chicago, Ill.
BROOKS, J., (M-3), Sargent & Co., New Haven, Conn.
CARMODY, A. J., (M-4), 221 Market St., Hartford, Conn.
CAREY J. E., (M-1), 268 Bryant Avenue, Syracuse, N. Y.
CARY, C. R., (A-3), Leeds & Northrup Co., Philadelphia, Pa.
CATLUND, R. O., (M-3), Madsen Iron Works, Huntington Park, Cal.
CINCINNATI MILLING MACHINE CO., (S-3), Cincinnati, O.
COLLIER, J. R., (M-3), 1332 Lakeland Avenue, Lakewood, O.
CONNELL, W. L., (M-10), 2932 First Ave., S., Minneapolis, Minn.
DRENK, C. F., (M-3), 233 Marconi St., Huntington Park, Cal.
DUCHEMIN, F. J., (M-3), 4734 Main Ave., St. Bernard, Ohio.
EARL, S. R., (M-3), 2227 E. 38th St., Los Angeles, Cal.
ERICSON, C. A., (M-4), 523 S. 4th Street, Minneapolis, Minn.
FARRAR, WM. W., (A-3), 769 Central Ave., Los Angeles, Cal.
FOSTER, C. S., (M-5), Fales-Jenks Machine Co., Pawtucket, R. I.
FURMAN, W. F., (A-3), Cutler Steel Company, New York City.
GARDNER H. L. V., (M-4), 124 Clover St., Syracuse, N. Y.
GIBBONS, F. L., (A-4), Central Steel Co., 904 Swetland Bldg., Cleveland, O.
GRAHAM, C. A., (M-4), 14656 Scripps Ave., Detroit, Mich.
HAGLUND, A. G., (M-3), 1124 Spence St., Los Angeles, Cal.
HARRY, H. E., (M-4), 89 Stevens Ave., Highland Park, Mich.
HOLMES, R. M., (M-4), 513 E. Dayton St., South Bend, Ind.
HUPP MOTOR CAR CORP., (S-4), Detroit, Mich.
JARDH, W., (M-3), 348 W. 68th St., Los Angeles Cal.
JOHNSON, V. G., (M-3), 520 Leland Ave., Waterloo, Iowa.
JONES, R. H., (A-3), 1400 Portland Ave., Minneapolis, Minn.
KING, W. A., (M-4), Abbott Ball Co., Elmwood, Conn.
KNOX, N. R., (M-3), 285 Ogden Ave., Milwaukee, Wis.
LAMBERT, P. F., (M-3), Box 171, Stockdale, Pa.
LAWRENCE, T. J., (M-4), 4305 Virginia Park, Detroit, Mich.
LONGLEY, G. S., (A-3), 162 Capitol Ave., Hartford, Conn.
MEAD, L. W., (A-3), 1537 West Ave., Los Angeles, Cal.
MILLER, C. P., (M-3), 1726 S. Oxford Ave., Los Angeles, Cal.
MOLINE PLOW CO., (S-4), Plow Works, Moline, Ill., Att: E. R. Guyer.
MOLINE PLOW CO., (S-3), Tractor Works, Moline, Ill., Att: C. B. Rose.

MORELAND, G. E., (M-3) Box 937—R. F. D. No. 2 Los Angeles, Cal.
MORSE, A. J., (M-3), 2176 E. 9th St., Los Angeles, Cal.
NENNINGER, L. E., (M-3), 2745 Erie Ave., Cincinnati, O.
NICHOLLS, V., (M-4), 940 W. Linden St., Bethlehem, Pa.
NILES TOOL WORKS CO., (S-3), Hamilton, O.
OBERHELLMAN, T. A., (M-3), 2801 LaSalle St., St. Louis, Mo.
OPPENHEIMER, A. E., (M-3), 2019-7th Ave., Moline, Ill.
OUTCALT, D. D. A., (Sb-3), 2124 N Anderson St., Tacoma, Wash.
PAYNE, H. F., (M-4), c/o 3701 Cortland St., Chicago, Ill.
PITCHER, B. G., (A-2), Keystone Refractories Co., 120 Liberty St., New York City.
POLLAK STEEL CO., (S-3), Cincinnati, O.
POTTER C. B., (A-4), 1900 Wrigley Bldg., Chicago, Ill.
R. & V. MOTOR CO., (S-4), Att: H. A. Holder, Pres., E. Moline, Ill.
RICH STEEL PRODUCTS CO., (S-3), 3855 Santa Fe Ave., Los Angeles, Cal.
ROCKFORD GAS LIGHT & COKE CO., (S-4), 201 Mulberry St., Rockford, Ill.
ROHLAND, L. E., (A-3), Poldi Steel Corp. of America, New York City.
SCULLEN, D. V., (M-4), 60 Euclid Ave. W., Detroit, Mich.
SHAFER, G. E., (M-4), Rickert-Shafer Co., Erie, Pa.
SHERMAN, J. D., (M-4), 187 Dufferin St., Toronto, Ont., Can.
STANEK, E., (M-3), 4247 W. Cullerton St., Chicago, Ill.
STEELE, WM. A., (Jr-3), 5511 Baywood St., Pittsburgh, Pa.
STEPHAN, G. B. Jr., (M-3), 13 Barnett St., New Haven, Conn.
STOKES, J. E., (M-4), 420 Grandview Blvd., Bethlehem, Pa.
THRASHER, C. O., (M-3), 2227 E. 38th St., Los Angeles, Cal.
TOOL STEEL GEAR & PINION CO., (S-2), Cincinnati, O.
TOWNLEY, C. F., (M-4), Gladstone Hotel, Detroit, Mich.
TRIMMER, C. R., (A-3), 412 Loan & Trust Bldg., Milwaukee, Wis.
U. S. PLAYING CARD CO., (S-4), Cincinnati, Ohio.
VOSMER, G. W., (M-4), 3319 Fairfield Ave., Cincinnati, O.
WELLS, A. J., (M-3), 3851 Santa Fe Ave., Los Angeles, Cal.
WESTPHAL, G. E., (M-3), 527 Haney Ave., South Bend, Ind.
WHITFORD, C., (M-3), 131 Baker Ave., Syracuse, N. Y.
WILD, C. J., (M-3), Box 639, Sta. "C", Los Angeles, Cal.
WITTEMAN, G. P., (A-3), 136 N. 50th St., Philadelphia, Pa.
WOLFE, H. L., (M-4), Rockford Gas Light & Coke Co., Rockford, Ill.
WRAY, T., (M-4), Washburn Wire Co., Providence, R. I.
YELLOW SLEEVE VALVE ENG. WORKS, INC., (S-3), c/o A. A. Gustafson, E. Moline, Ill.

CHANGES OF ADDRESS

BAKER, R. E., from Rock Island Arsenal, Rock Island, Ill., to Box 286, Cleveland, Tenn.
BECKER, M. E., from 329 Church St. to 368 Main St. Hartford, Conn.
BELIAEFF, S. S., from P. O. Box 44, Troy, N. Y., to P. O. Box 189, Passaic, N. Y.
BIXBY, A. B., from 315 Peebles St., Sewickley, to 41 Harwood St., Pittsburgh, Pa.
CLARK, K. L., from 572 W. Randolph St., to 400 N. Sangamon St., Chicago, Ill.
COMSTOCK, G. D., from 208 Farmington Ave., Hartford, to 675 Broad St, Meriden, Conn.
CROSSMAN, L., from 27 Richards St., Worcester, Mass., to 285 Main St., Bristol, Conn.
DAVIS, G. F., from Bowling Green, Mo. to 715 S. Walnut Bucyrus, O.
ECKENRODE, C. A., from 3441 Forbes St., to 351 Darrah St., Pittsburgh, Pa.
EMERY, R. E., from Crucible Steel Co. of America, LaBelle Works, to 525 Union Trust Bldg., Pittsburgh, Pa.
FREDERICK, J. B., from 2203 Auburn St., to Care Pool Hotel, Rockford, Ill.
HALBING, J. E., from Ingersoll Rand Co., to 631 Barrymore St., Phillipsburg, N. J.
HART, A., from 107 Liberty St., to 44 Whitehall St., New York City.

HOVEN, J. R., from 823 Washington Ave., to 424 Tribune Annex, Minneapolis, Minn.
HULL, J. E., from 20 Mathewson St., to P.O. Box 1, Providence, R. I.
KRYNITSKY, A. I., from P.O. Box 258 to 3609 37th St., Mt. Ranier, Md.
LASCHUK, S., from 835 N. Robey St., to 733 S. Karlov Ave., Chicago, Ill.
LEONARD, S. C., from 5307 Cornell Ave., to 5525 Hyde Park Blvd., Chicago, Ill.
LUCAS, H., from Apt. A, 414 W. Washington to 312 S. Wm. St., South Bend, Ind.
McLEAN, John, from 51 Galt St., to 8 Fulton Ave., Sherbrook, Quebec, Can.
MAROT, E. H., from 2301 W. Euclid Ave., to 7404 Hanover St., Detroit, Mich.
McBRIDE, A. T., from 311 Beech St., to Edgewater Steel Co., Oakmont, Pa.
MILLER, C. C., from 2611 Madison St., to 2622 Jefferson St., N.E., Minneapolis, Minn.
MIRANDO, J. F., from 1030 Cypress St., to 3123 Ogden Ave., Chicago, Ill.
NESSER, J. O., from 7705 John R., to 10230 Oakland Ave., Detroit, Mich.
OSWALD, G. J., from 116 Colorado Ave., to 2322 N. Main St, Dayton, O.
PITTS, C. M., from Althea Ave., to 1110 Guilford Ave., Baltimore, Md.
QUINN, J. M., from 34 Lavin Court, Troy, N. Y., to 5309 Prairie Ave., Chicago, Ill.
REICHHELM, P. F., from 24 John St., New York City to Elizabeth, N. J.
RINEK, J., from Crucible Steel Co. of America, Jersey City, N. J., to Crucible Steel Co. of America, Harrison, N. J.
STARGARDTER, A. R., from Marlborough Apts., Baltimore, Md., to 2416 "B" St., Granite City, Ill.
TAPPER, G. W., from 413 Seitz Bldg., to 508 Turtle St., Syracuse, N. Y.
TUCKER, W. L., from 606 N. Pine Ave., Chicago, Ill., to 42 Commercial Rd., Hyde Park, South Australia.
VAN DYKE, F. J., from 3470 Gibson to 2181 Cortland Ave., Detroit, Mich.
WOODWARD, A. F., from 69 Stevens St., to 49 Second St., Lowell, Mass.

MAIL RETURNED

FOWLER, H. R., 42 Orchard Street, Cambridge, Mass.
SATTER, F. N., 968 Eddy Road, Cleveland, Ohio.
SCHINDLER, Arthur, 6146 15th Street, Detroit, Mich.

Items of Interest

THE Ludlum Steel Co. announce that they have recently opened a Boston office which is in charge of E. R. S. Reeder. Prior to the opening of this office the Wheelock, Lovejoy & Co. of Cambridge, Mass., were the local representatives of the Ludlum Steel Co. Mr. Reeder has been branch manager for many years and recent manager of the tool steel sales of the Wheelock, Lovejoy & Co.

The new office is located at 1004 Little building, 80 Boylston street, Boston, Mass. The general office of the Ludlum Steel Co. is at Watervliet, New York.

Charles T. Bragg, formerly chief metallurgist of the Michigan Smelting & Refining Co. and more recently president of the Michigan Valve & Foundry Co., has resigned from the latter position.

Henry J. Fischbeck is in charge of heat-treating for the Lawrence Aero-Engine Corp., New York City. He was previously foreman for the Wright Aeronautical Corp., Paterson, N. J.

The Witherow Steel Co. of Pittsburgh, has plans in progress for extensions and improvements at its plant at Neville island, to double, approximately, the present capacity. The company has recently formed a merger with the River Front Land Co. in this section, and has advanced its capital to $2,800,000 for general expansion. W. P. Witherow is president and Joseph Dilworth secretary of the company.

The Youngstown Sheet & Tube Co. has removed its Pittsburgh office from 1626 Oliver building to the suite formerly occupied by the Brier Hill Steel Co., rooms 1912-1914.

The Bureau of Standards has studied the ingot structure of ingots of invar (Fe:Ni 65:35) and the relation of the structure to the forgeability of the alloy. It has been found that ingots cast in chilled molds cool too slowly and form excessively large columnar crystals, producing a very brittle ingot which breaks readily on forging. To correct this difficulty a specially designed and refrigerated mold must probably be used.

The Pittsburgh station of the United States Bureau of Mines is devising

an instrument to record continuously carbon monoxide over a range of concentrations up to about 10 parts in 10,000. When the instrument is set up, it will be calibrated with known mixtures of carbon monoxide in air. If it proves practicable, the instrument can be used around blast furnaces, metallurgical and chemical plants and other places where a carbon monoxide hazard exists.

"Metals and Their Alloys," a very capable volume written by Charles Vickers, has recently been published by H. C. Baird & Co., 2 West Forty-fifth street, New York city.

This capable volume, while being partly based on "Metallic Alloys," by W. T. Brannt, has had so many revisions and additions by Mr. Vickers that a new book has resulted.

Many years of intimate contact and experience in the casting industry has fitted the author admirably for this work. The book is admirably fitted to the needs of the plant manager, the metallurgist, the chemist, or the worker in the shop. It is intensely practical and has been given a simple and direct treatment.

The author discusses the casting of copper, the making of manganese bronze, aluminum bronze, aluminum alloys, red brass, yellow brass, machine metals, and nickel alloys, together with their physical properties and attending peculiarities. The physical properties including strength, ductility, toughness, lightness, color, hardness, conductivity and resistivity, or the properties which make them admirably suited for bearings are dealt with in this volume. Many valuable formulas are included in this work. These formulas are given in such a way as to be easily understood by even the novice and the methods and procedure of mixing metals are set forth in considerable detail.

Some of the new and less frequently met with alloys are discussed. In addition there is a chapter that deals with die-casting, die-casting methods, die-casting bronze, and some of the lower melting point die-casting metals.

For those interested in the origin and physical properties of the elements; the methods of obtaining them from their ores and refining them, will find the large amount of information included in this book to be of considerable value.

In addition to the work taken from Brannt, entirely new chapters have been added to modernize the work thus bringing it up with the great developments of the industry within recent years.

"Metals and Their Alloys" is a thoroughly practical book, descriptive of the best American practices in dealing with metals and their alloys and is undoubtedly unapproached by any similar work in any language. There is no doubt that it will fill a long felt want in the industry and one which it aims to cover.

The volume is 6 x 9, containing 760 pages, and is bound in cloth. Price, $7.50.

The Bethlehem Steel Co. has announced the following appointments of individuals who were in the sales organiation of the Midvale Steel & Ordnance Co.: L. B. Morris, Midvale New York district sales manager, is now Bethlehem representative located in the Monadnock building, San Francisco. J. L. Adams has been appointed sales agent of Bethlehem in Cincinnati, and J. E. McLain, former Midvale Pittsburgh sales manager becomes Bethlehem Pittsburgh sales agent. A. C. Howell, Midvale Philadelphia district sales manager becomes plate sales agent for Bethlehem. L. R. Steuer has been put in charge of general sales of billets, wire rods, etc., with headquarters at Bethlehem, Pa.

The Chicago Flexible Shaft Co., 5600 Roosevelt road, Chicago, have available for distribution a new folder on their Stewart industrial furnaces. These are built for a wide number of uses, including annealing, carburizing, hardening, drop forging, high-speed steel, tempering, metal melting, and welding. Particular stress is laid on the proper equipment for high speed steel; advantages named for the company's furnaces are: minimum of heat radiation with consequent uniform temperature, accurate control, and decreased fuel consumption.

The publishers, Adam Hilger, Ltd., 75 A Camden Road, London, Eng., announce that the book entitled, "Wavelength Tables for Spectrum Analysis," compiled by F. Twyman, F. Inst. P., is now ready for distribution.

This book is a collection of wavelength tables intended for use in the laboratory, containing only matter essential for this purpose. It comprises standard wavelengths from 2375 to 8495, I.A., the persistent and sensitive lines of most of the elements arranged under the name of each element and the most persistent lines arranged in the order of wavelengths.

There is also a list of wavelengths useful in the determination of stellar radial velocities.

For the standard wavelengths the recommendations of the International Solar Union and the International Astronomical Union have been followed.

For the tables of distinctive lines of the elements, the results of Hartley, of Leonard & Pollok and of A. de Gramont have alone been utilized. The object has been not to give complete tables of the wavelengths of the elements but to give those lines which are present when the quantity of the element is extremely small, and the authors cited are the ones who have given this problem most attention.

R. H. Goodrich has become engineer for the Detroit Motor Casting Co., Detroit.

EMPLOYMENT SERVICE BUREAU

The employment service bureau is for all members of the Society. If you wish a position, your want ad will be printed at a charge of 50c each insertion in two issues of the Transactions.

This service is also for employers, whether you are members of the Society or not. If you will notify this department of the position you have open, your ad will be published at 50c per insertion in two issues of the Transactions. Fee must accompany copy.

Important Notice.

In addressing answers to advertisements on these pages, a stamped envelope containing your letter should be sent to AMERICAN SOCIETY FOR STEEL TREATING, 4600 Prospect Ave., Cleveland, O. It will be forwarded to the proper destination. It is necessary that letters should contain stamps for forwarding.

POSITIONS WANTED

WANTED—POSITION AS SUPERVISOR of a heat treating department. Have had 12 years experience in heat treating, tool and die hardening. Address 4-5

WANTED—POSITION AS HARDENER. Have had 5 years practical experience with a large firm in general hardening of both carbon and high-speed steel as well as carburizing. Fully competent. Age 35. Married. Address 4-10.

METALLURGIST WITH 8 YEARS EXPERIENCE in the analysis of ferrous and nonferrous metals, physical testing, metallography and heat treatment of plain and alloy steels, desires responsible position in laboratory of well established concern. Address 4-15.

POSITION IS DESIRED AS FOREMAN OF HEAT TREATING DEPARTMENT. Seven years of high grade experience with carbon, high speed, and alloy steels, covering all phases of heat treating. Best references. Address 4-20.

POSITION WANTED IN METALLURGICAL LABORATORY. Seven years of high grade experience in metallographic testing, research work and experimental heat treating; also pyrometry technical training. Best references. Address 4-25.

EXPERIENCED TOOL HARDENER would like a position in or around New York. Has had 11 years experience. Can harden and carburize all kinds of steel. Can give first class references if desired. Address 4-30.

AS WORKS SUPERINTENDENT with 16 years of high grade experience in all branches of tool and metal parts manufacturing. Can assure maximum quality production at a minimum cost. Best of references. Address 4-35.

METALLURGIST—Desires Position—Nine years experience both in research and production in tool steel mills, standardization heat treatment of tool steels, metallography ferrous and non-ferrous metals, pyrometry, physical and chemical testing. Address 2-15.

ASSISTANT METALLURGIST. Ten years practical experience in heat treating department and laboratory of several well known concerns. Boston district preferred. Salary $150.00 per month. Married. Address 10.

POSITIONS OPEN

DIE BLOCK DESIGNER and hardener wanted by an eastern concern who manufacture die blocks. This position offers an excellent opportunity for one who has had experience in both the designing and hardening of blocks. State experience and qualifications. Address 4-40.

GRADUATE METALLURGIST—Recent metallurgical graduate wanted for metallurgical department of a tool steel mill. Opportunity for experience and advancement. Western Pennsylvania. State in reply, education, age and experience, if any. Give three references. Address 3-10.

TOOL STEEL SALESMAN. New England States. Prefer one acquainted with the trade and now handling similar line. Do not apply unless you have had experience. This is one of the largest tool steel companies in the country, and affords a splendid opportunity for the right man. Address 3-5.

TECHNICAL GRADUATE with 2 years (or possibly less) experience. Preferably graduate in mechanical engineering with testing materials experience or training. Man would have variety of work such as mixing alloys, testing of materials and helping with miscellaneous experiments. Approximate salary $150 per month. Location Cleveland. Address 2-25.

TECHNICAL GRADUATE to assist in experimental work in metallographic laboratory preferably with training in physical measurements. Metallurgical training or experience desirable but not absolutely necessary. Approximate salary $150.00 per month. Location Cleveland. Address 2-20.

FOREMAN TO SUPERVISE PRODUCTION in a steel treating department employing 20 to 30 men. Large tractor plant requiring carburizing and full heat treatment of carbon and alloy steels. Position requires familiarity with modern methods and equipment. Address 5-1.

WANTED A THOROUGHLY COMPETENT, energetic man, preferably techical, to sell pyrometers, regulators, etc., in Michigan District. Only high grade men who can produce results need apply. Give present employment, age, married or single, training, references, and income expected. Address 5-5.

The Interstate Iron & Steel Co., Chicago, has recently made the following announcement concerning the personnel of their organization:

H. S. Schroeder, formerly manager of the New York office, has been appointed sales manager of the bar division, with headquarters in the Chicago office.

F. C. Giebel is now in charge of the New York office at 52 Vanderbilt avenue.

St. Paul, is now a branch office. R. W. Wentworth is district sales manager. The address of this office is 522 Merchants' National Bank building.

William Jessop & Sons, Inc., of 91 John street, New York City, announce that they are opening a warehouse in Cleveland in which they will stock their regular line of products including bars and sheets.

The Cleveland office and warehouse will be under the direction of V. M. Wellman and its permanent location will be announced in an early issue of TRANSACTIONS.

Mr. Wellman is a member of the Cleveland chapter of the A. S. S. T., and has been very active in the work of the chapter.

Westinghouse Electric & Manufacturing Co. announce changes in the Los Angeles offices. The power division has been changed to the central station division with J. C. Jones as manager, Mr. Jones is also in charge of sale of supply apparatus in that territory. The railway division has been changed to the transportation division with G. B. Kirker as manager. A merchandising division has been established with J. H. Jamison as manager, and an engineering division with R. A. Hopkins as manager..

Louis W. Williams, for the past 10 years manager of the New York office and warehouse of the Union Drawn Steel Co., on April 1 joined the Cauldwell-Wingate Co., 381 Fourth avenue, New York.

Harry A. Trautman has been appointed manager of production for the K-W Ignition Co., Cleveland. He was until recently foreman of the heat-treating department of the Steel Products Co., also of Cleveland.

Herman A. Holz, New York City, is distributing a catalog entitled "The Holz Thetascope," which describes an apparatus for the reliable and convenient measurement of the characteristic "angle of contact" ("theta") between liquids and solids and is particularly useful for the determination of the "lubricating efficiency" of oils and greases based upon their adhesive forces to metal surfaces.

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